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ABSTRACT

A project summary and 20 related papers are presented on the Argonne Braille Machine, a device which produces braille-equivalent information on magnetic tape rather than embossing dots on paper. The summary traces the machine's development while 10 papers cover such issues as user reactions, evaluation proposals, use and care of the machine, the braille reading process, and the system's advantages. An additional 10 papers focus on auxiliary equipment and computer translation. The final section includes information on the U.S. patent for the Argonne Braille Machine, letters and awards in recognition of its development, and sample related news clippings. (CL)

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THE ARGONNE BRAILLE PROJECT

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ANL/ENG-77-01

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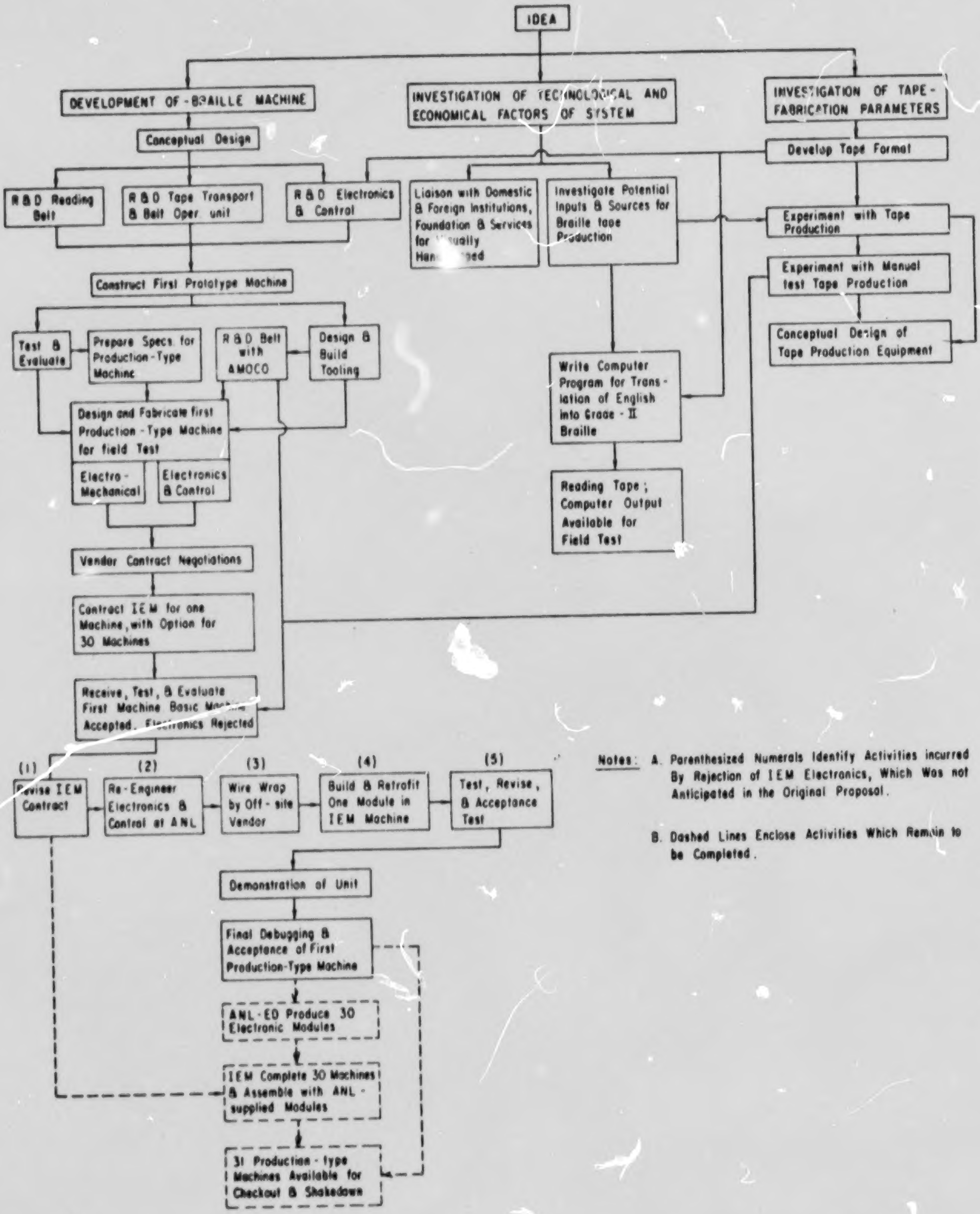
THE ARGONNE BRAILLE PROJECT

Arnold Grunwald
Principal Investigator

Engineering Division

July 1977


IDEA
DEVELOPMENT OF BRAILLE MACHINE
INVESTIGATION OF TECHNOLOGICAL AND ECONOMICAL FACTORS OF SYSTEM
INVESTIGATION OF TAPE-FABRICATION PARAMETERS
Conceptual Design
Develop Tape Format
R & D Reading Belt
R & D Tape Transport & Belt Oper unit
R & D Electronics & Control
Liaison with Domestic & Foreign Institutions, Foundation & Services for Visually Handicapped
Investigate Potential Inputs & Sources for Braille tape Production
Experiment with Tape Production
Experiment with Manual test Tape Production
Conceptual Design of Tape Production Equipment
Construct First Prototype Machine
Test & Evaluate
Prepare Specs for Production-Type Machine
R & D Belt with AMOCO
Design & Build Tooling
Write Computer Program for Translation of English into Grade-II Braille
Design and Fabricate first Production-Type Machine for field Test
Electro-Mechanical
Electronics & Control
Reading Tape; Computer Output Available for Field Test
Vendor Contract Negotiations
Contract IEM for one Machine, with Option for 30 Machines
Receive, Test, & Evaluate First Machine Basic Machine Accepted. Electronics Rejected
(1)
Revise IEM Contract
(2)
Re-Engineer Electronics & Control at ANL
(3)
Wire Wrap by Off-site Vendor
(4)
Build & Retrofit One Module in IEM Machine
(5)
Test, Revise, & Acceptance Test
Demonstration of Unit
Final Debugging & Acceptance of First Production-Type Machine
ANL-ED Produce 30 Electronic Modules
IEM Complete 30 Machines & Assemble with ANL-supplied Modules
31 Production-type Machines Available for Checkout & Shakedown

Notes: A. Parenthesized Numerals Identify Activities incurred By Rejection of IEM Electronics, Which Was not Anticipated in the Original Proposal.

B. Dashed Lines Enclose Activities Which Remain to be Completed.

Evolution of the Argonne Braille Machine.

ACKNOWLEDGMENTS

The U. S. Department of Health Education and Welfare Office of Education Bureau for the Education of Handicapped Children has funded the effort described and fostered some of the ideas presented in this report. The Illinois Visually Handicapped Institute, the Missouri School for the Blind and the South Metropolitan Association (of school districts) have kindly allowed us to use their facilities; teachers and students as well as individual participants and several volunteer transcribers have all been associated in the program, as have several divisions of Argonne National Laboratory, listed below:

Accelerator Research Facilities
Applied Mathematics
Central Shops
Electronics
Engineering
Quality Assurance

The following people have made significant contributions in the development of the Braille Project:

P. Biesemeier
R. Foster
G. Grunwald
J. Haasl
E. Kolsto
B. Kroupa
L. Leffler
W. Lidinsky
T. Pienias
S.M. Prastein
R. Vonderohe

For attribution of specific parts of the program, the reader is referred to the authorship noted on each section of this report.

TABLE OF CONTENTS

Page

Frontispiece: Evolution of the Argonne Braille Machine iii

Acknowledgments iv

I. Final Report Summary (A. Grunwald) I-1

II. Papers on Argonne's Braille Machine (if not otherwise indicated, in numbered Argonne Reports)

A. Testing Argonne's Braille Machine (A. Grunwald and P. Biesemeier) II-A-1
Reading data and user reactions are presented.

B. Braille Machine Experience (A. Grunwald and P. Biesemeier) II-B-1
Eight users (mostly young adults and good braille readers) comment on the Braille Machine experience; three case histories are presented.

C. Field Study Plan for the Argonne Braille Machine (A. Grunwald and P. Biesemeier) II-C-1
A field study plan, including procedure, subjects, and data analyses, is proposed to test the utility of the Argonne Braille Machine.

D. How to Use the Braille Machine (P. Biesemeier) II-D-1
A user's guide explains how to read, write, index, and load the Braille Machine; suggestions for care of tapes and machine are made.

E. Development of the Argonne Braille Machine - Summary Status Report, December 1972 (A. Grunwald et al.) II-E-1
The development of the Braille Machine is outlined, and work remaining to be done, fabrication of 30 machines, and generation of reading tapes are described.

Table of Contents (Cont'd)

Page

F. Case History of a Bio-Engineering Project, The Argonne Braille Machine (A. Grunwald, RESA Lecture, March 9, 1972) II-F-1

The braille reading process is examined and maximum reading speeds are determined, as preliminaries to designing a braille machine with moving braille characters.

G. The Argonne Braille Machine (Argonne News Release, Sept. 1969) II-G-1

The advantages of the system -- less bulk, less expense, and greater variety and volume of literature -- are discussed.

H. A Magnetic Tape Braille Machine (J. Haasl and W. Lidinsky, ANL T.M. 176, April 1969) II-H-1

The system approach, electronic memory and control package, and read-write electronics for the new Braille System are described.

I. On Reading and Reading Braille (A. Grunwald, Proceedings Braille Research and Development Conference, sponsored by Sensory Aids Evaluation and Development Center, M.I.T., 1966) II-I-1

Results of braille reading tests, with and without vocalization and with continuous as well as random patterns, indicate that pattern recognition in reading is not correlated to comprehension and is a dynamic rather than a static process.

J. A Braille Reading Machine (A. Grunwald, SCIENCE 154 (1966) 144-146) II-J-1

The Braille Machine concept is presented, together with experiments to determine specifications for the device, and reader preference with regard to different modes of braille presentation.

Table of Contents (Cont'd)

Page

III. Papers on Auxiliary Equipment, Computer Translation, etc.

A. The Reading Belt of the Braille Machine (A. Grunwald) III-A-1
Belt performance is analyzed both objectively and subjectively. Remaining problems include dot height belt deterioration and weld distortion.

B. The Beltmaker (A. Grunwald and T. Pienias) III-B-1
The Beltmaker is described and directions for its proper use and maintenance are given.

C. Argonne Tape Production Facility Systems Description (R. Foster and W. Lidinsky - ANL T.M. 308, June 1977) III-C-1
The operation of the Tape Production facility is described, including both the system hardware and the system software.

D. Argonne Braille Machine Tape Production Facility User Guide (R. Foster - ANL T.M. 307, June 1977) III-D-1

E. Argonne Portable Braille Input Editor (B. Kroupa, W. Lidinsky, and A. Grunwald - ANL T.M. 309, June 1977) III-E-1
A device, based on the Perkins Brailler, is described which (in conjunction with the Braille Machine) allows an operator (who may be blind) to write on magnetic tape; the tape may be read back on the Braille Machine. For editing and correcting the input before recording, a paper braille copy is presented to the operator.

F. An On-Line System for Immediate Braille Presentation of Computer-Stored Information to the Blind (A. Grunwald and R. Vonderohe, 1972 Carnahan Conference on Electronic Prosthetics, Lexington, Kentucky Sept. 1972) III-F-1
Procedures are described which permit using the braille display mechanism of the Argonne Braille Machine in a computer terminal for blind clerical workers in lieu of the C.R.T. devices commonly used in such applications.

Table of Contents (Cont'd)

Page

G. The Development of a Computerized Grade II Braille Translation Algorithm (L. Leffler, A. Grunwald and W. Lidinsky, 1971 Wescon Conference, San Francisco) III-G-1
The development of a computerized modular translation system is described. Acceptable Grade II Braille tapes can be produced for use on the Argonne Braille Machine.

H. The Argonne Braille Translator (L. Leffler and S. M. Prastein) III-H-1
The Argonne Braille Translator transforms typesetter-oriented input (such as monotype paper tape) into a master magnetic tape suitable for replication of tape for the Argonne Braille Machine.

I. Prospects for Utilization of Compositor's Tape in the Production of Braille (G. Grunwald) III-I-1
Information obtained from a literature search, a questionnaire, and interviews with publishing houses suggests that compositor's tape will have little effect on Braille production: very few titles get on tape completely; tapes are kept only briefly after printing; and different formats are used.

J. IBM 1403 Printer Modifications for Computerized Braille Output (E. Kolsto, ANL Report 7812, July 1971) III-J-1
To produce Braille computer output on an IBM 1403 line printer, resilient rubber is stretched in front of the printer hammers to serve as a cushion; rows of dots are printed, creating braille characters on the reverse side of the paper, by use of a simple set of instructions to the machine.

10

Table of Contents (Cont'd)

Page

IV. Letters and Awards in Recognition of the Development of the Argonne Braille Machine

A. United States Patent 3,624,772, Reading and Writing Machine Using Raised Patterns, issued Nov. 30, 1971 This patent for the Argonne Braille Machine describes and illustrates the tape, tape drive mechanism, and reading belt; use of the machine for both reading and writing is detailed. IV-A-1

B. Letter from Department of Health, Education, and Welfare August 17, 1976. IV-B-1

C. Letter to Editor of SCIENCE Magazine from L. L. Clark, Director, International Research, American Foundation for the Blind, October 14, 1966. IV-C-1

D. News Release and Letter from President Richard Nixon, February 13, 1970. IV-D-1

E. I·R 100 Award, 1969. IV-E-1

F. News Clippings. IV-F-1

I. FINAL REPORT SUMMARY - A. Grunwald

FINAL REPORT SUMMARY

The Braille Machine has reached the stage where development of the system appears both possible and desirable.

The idea for a "Summary for Compact Storage of Information on Magnetic Tape, readable by Touch as Braille Characters by Means of a Portable Reading Machine" was described in our publication in SCIENCE in October 1966; a proposal to develop this system was submitted to HEW in 1967, and the first funding was provided by the Office of Education (through the University of Chicago) in 1968. Based on the resulting early work, a patent application was filed in 1969, and the patent was granted in 1971. The first prototype machine was completed in 1969, followed by a production prototype in 1970. In 1971 the construction of 30 machines was authorized, and the machines were finally delivered late in 1975. These machines have since been extensively tested (on- and off-site, in laboratory environment and in close to "real-life" field-use situations, involving a total of 51 subjects). Numerous deviations from drawings and specifications by the manufacturer were found and corrected, and a number of design refinements have been incorporated since then, resulting in steadily increasing reliability and confidence.

When the extent of "shakedown testing" required was appreciated and the Laboratory was able to carry out "real-life" testing - O.E. had authorized us to hire a blind Psychologist (Ph.D.) as a combination "subject/coordinator/consultant" for this purpose - it was decided to integrate use and shakedown testing as much as possible in order to accelerate progress. A report on results of this work has been issued; an updated version will soon be published in final form, including 17 more subjects, mostly children in public schools from grade 1 up.

Within the framework of these central activities, the necessary system support technology has been developed. For example, power supplies incorporating rechargeable batteries were developed and constructed. Five Perkins Braillers were purchased and equipped with electronic switching-memory-and control devices, permitting one to write directly on magnetic tape on the "basic" Braille Machine.

In addition, a "Tape Master Station" has been designed, built, and tested. This equipment is used for the production of (1/4 inch) reading tapes which contain the information in Grade II English Braille. A computer program to translate Standard English to Grade II Braille from tapes formatted as standard English text has been written, tested, and perfected. Several complete books have been translated to the format required by the Braille Machine. These have been produced from at least five different sources: compositor's (typesetter's) tapes; material which had been prepared for computer analysis of text by transcribing onto machine readable media; tapes and card decks containing braille formatted input; English text transcribed onto magnetic tapes on special tape-type and editing equipment by steno-typists (who need not know braille), for the purpose of generating Grade II Braille; and tapes written directly onto 1/4 inch tape in Grade II by braille transcribers with the equipment described above, i.e., Braille Machines and Writer/Editors. Several special tapes for testing of equipment, experimentation with various formats, evaluation of teaching methods, etc., were also prepared.

Finally, a large effort has beeen expended in the development, testing, refinement, and production of reading belts, and in the development, construction, testing and perfection of machinery to make belts and to do so economically.*

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* The belt is a consumable item; hundreds were used in the development of the belt itself and the machinery to make it and in the development and testing of the Braille Machine.

All these activities were directed and coordinated by the principal investigator. In addition, many individuals contributed their dedicated efforts and their competence and skills in several disciplines; ANL divisions involved were Engineering (overall design and management), Applied Mathematics (electronics, tape production, computer programming and operation), Electronics (fabrication of several subassemblies), Central Shops (prototypes, etc.) and High Energy Facilities Materials Section (plastics, etc.).

A necessary step now is to assemble a design review team from the fields of electrical and mechanical engineering, rehabilitation, libraries for visually handicapped, etc. The team should examine all design aspects of the system and issue a summary report of their findings and recommendations. It is expected that the team will suggest several technical modifications, including perfecting a selfthreading tape cartridge system, a belt-loading package or cartridge device. Also needed are a specific plan for transferring this technology from the laboratory and a strategy for further development and deployment.

Looking beyond these priority items, attention should be directed toward the best use for the existing machines. Belt and tape production capacity and maintenance and repair capability must be preserved, together with the experience and expertise in this area for transfer when a "recipient" has been identified. The production of a tape library (committing additional material to 1/4 inch Braille Machine format) should present little difficulty; tapes can be obtained from both presently-used sources and additional ones to be identified.

Photographs on the following five pages depict the external appearance of the Braille Machine and the three basic modules from which the device can be assembled in about five minutes.

The next two parts of the report are a collection of articles and papers by various individuals associated with the project; an abstract of each is given in the Table of Contents. In Part II, the issued testing report is reprinted, followed by earlier topical reports, back to the SCIENCE article describing the new system. The work required for the development of auxiliary equipment and for the computer translation, etc. is presented in Part III.

Finally, several letters and citations are reproduced in Part IV, in recognition of the development of the Argonne Braille Machine.

This long, exciting, often frustrating and yet deeply satisfying effort will have been successful only if and when blind users will reap the benefit of a vastly increased supply of braille material.

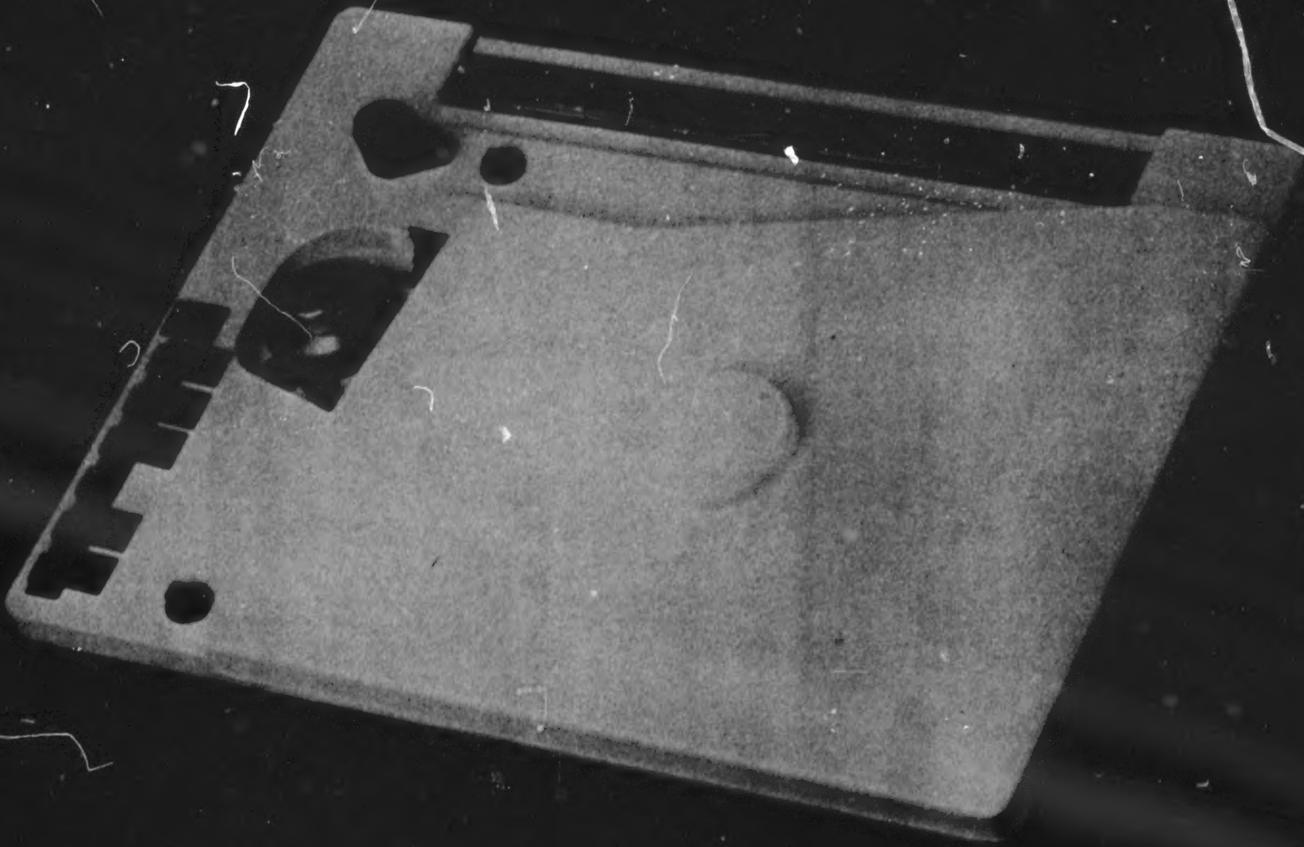

Figure 1. ARGONNE BRAILLE MACHINE READY FOR READING

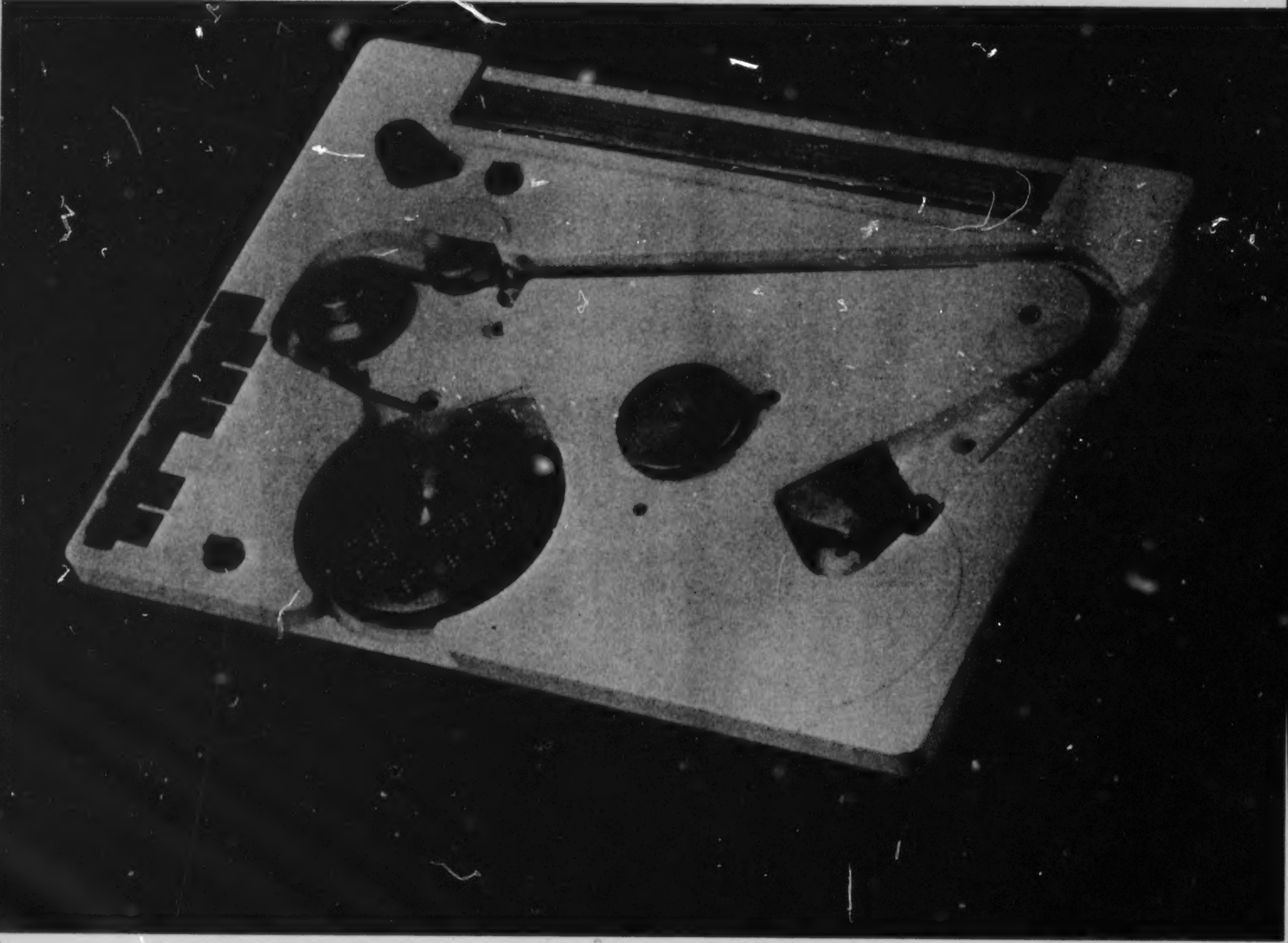

Figure 2. ARGONNE BRAILLE MACHINE WITH HANDGUARD REMOVED

Figure 3. TAPE DECK MODULE

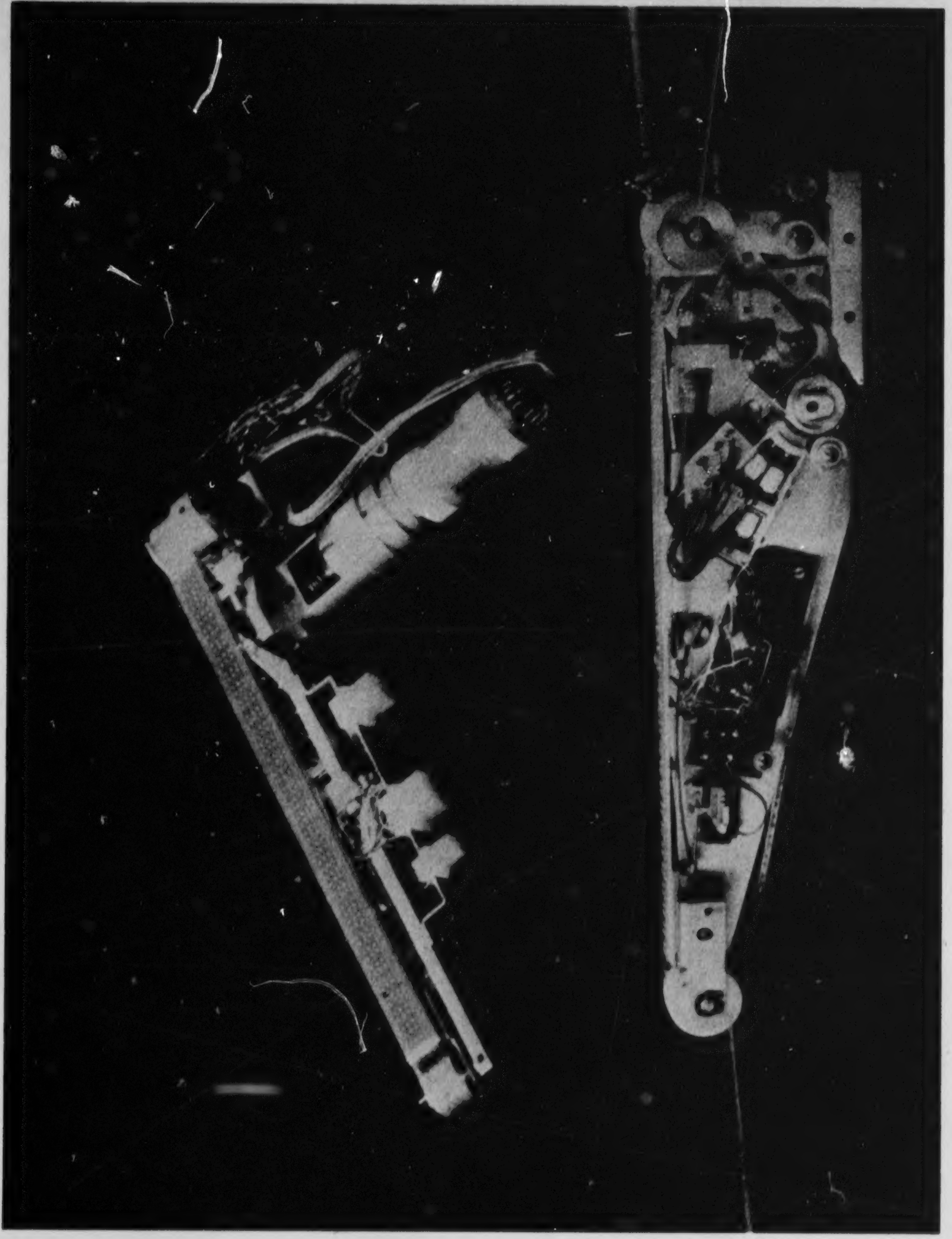

Figure 4. BELT MODULE

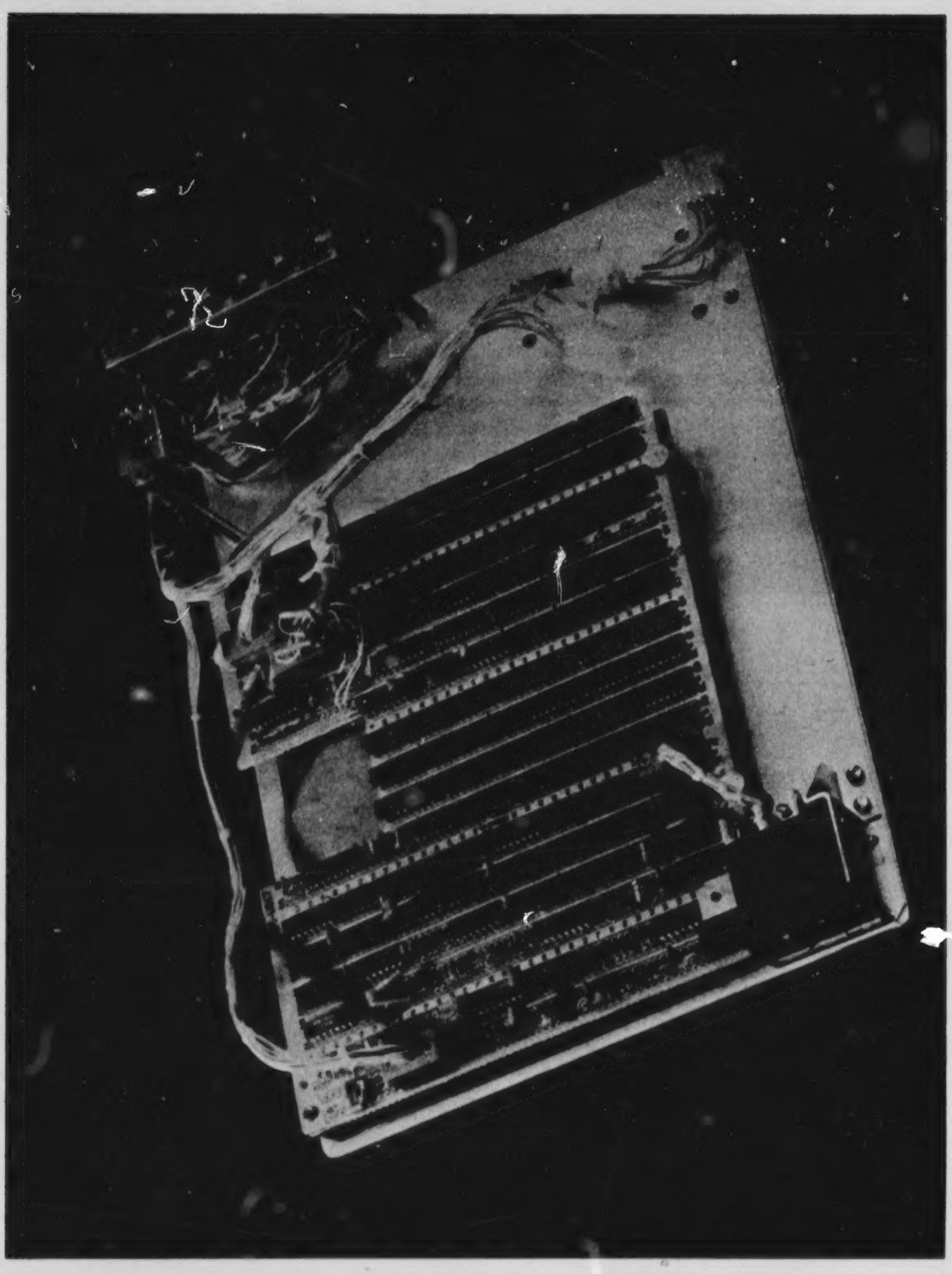

Figure 5. BASE PLATE WITH ELECTRONICS AND SWITCH GEAR

II. PAPERS ON THE ARGONNE BRAILLE MACHINE -

TESTING ARGONNE'S BRAILLE MACHINE

A. Grunwald and P. Biesemeier

Argonne National Laboratory has developed a new system for publishing and presenting braille text, which involves encoding braille-equivalent information on magnetic tape (rather than embossing actual dots on sheets of paper).(1) Such tapes, which are much smaller in volume than corresponding ink print books and typically less than one-hundred and fiftieth the volume of conventional braille, can be handled, shipped, and stored, as well as used, more conveniently and less expensively, and they may be produced at a fraction of the cost of conventional braille.

To read such tapes, a compact device (smaller than a portable typewriter) was developed to impress the braille text onto an endless belt that circulates under the reader's fingertips. The text is continuously written, and erased from the belt after it has passed under the reader's fingers. The belt can be read at various speeds and, if desired, "re-called." A blind user with such a machine is shown in Fig. 1. The reading machine alone, given an initial production of one thousand, would probably cost less than $2,000. The machine could also be used in combination with an electronic keyboard for writing and editing, based on the Perkins Brailler, for writing as well as for reading. This arrangement is shown in Fig. 2.

In addition to the tape medium and reading/writing machines, the new system includes several ways to generate tapes, indexing features, editing devices, duplicating machinery, and computer programs assisting in the production of Grade II Braille. All components were tested extensively and are now operational.

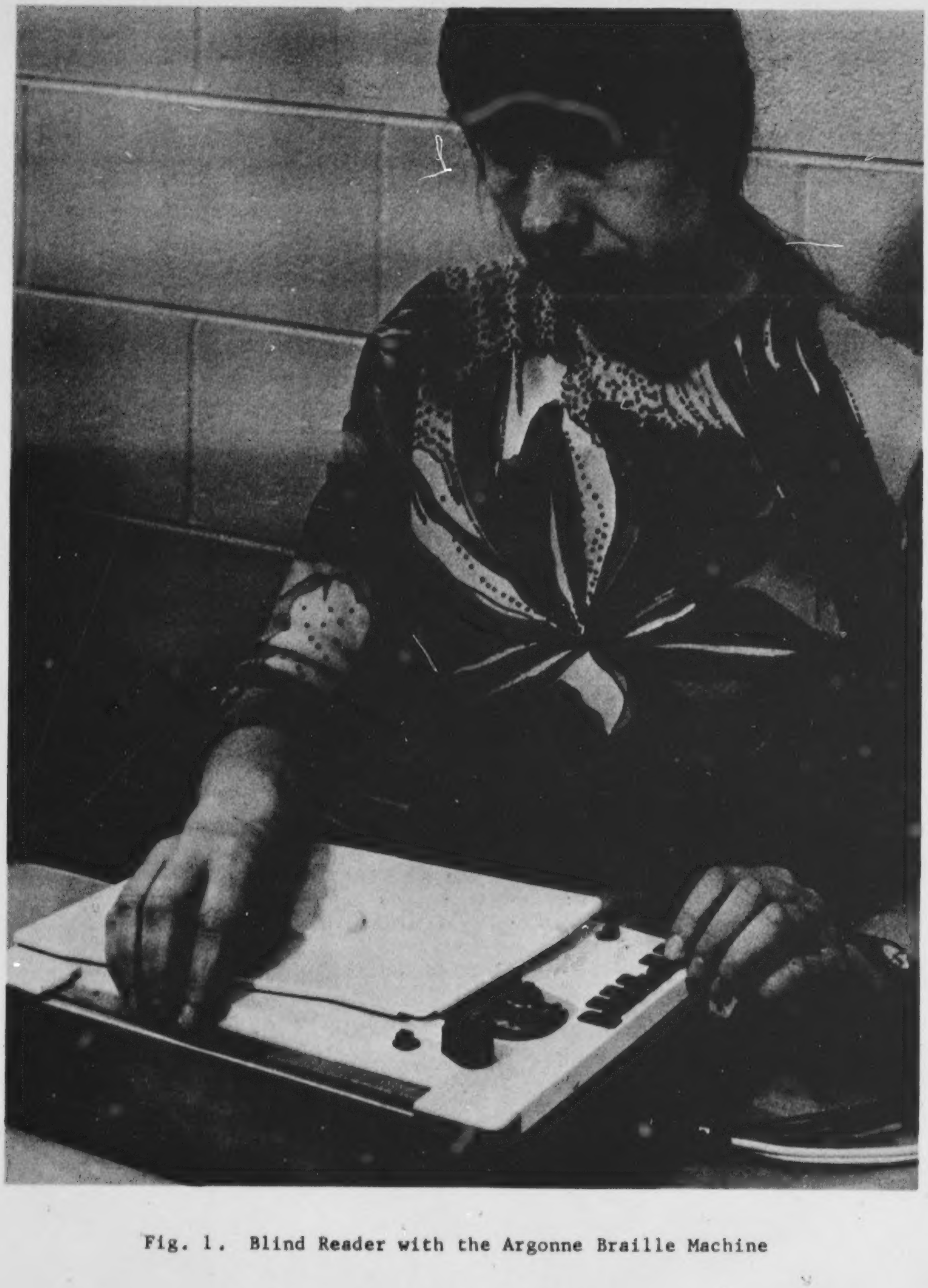

Fig. 1. Blind Reader with the Argonne Braille Machine

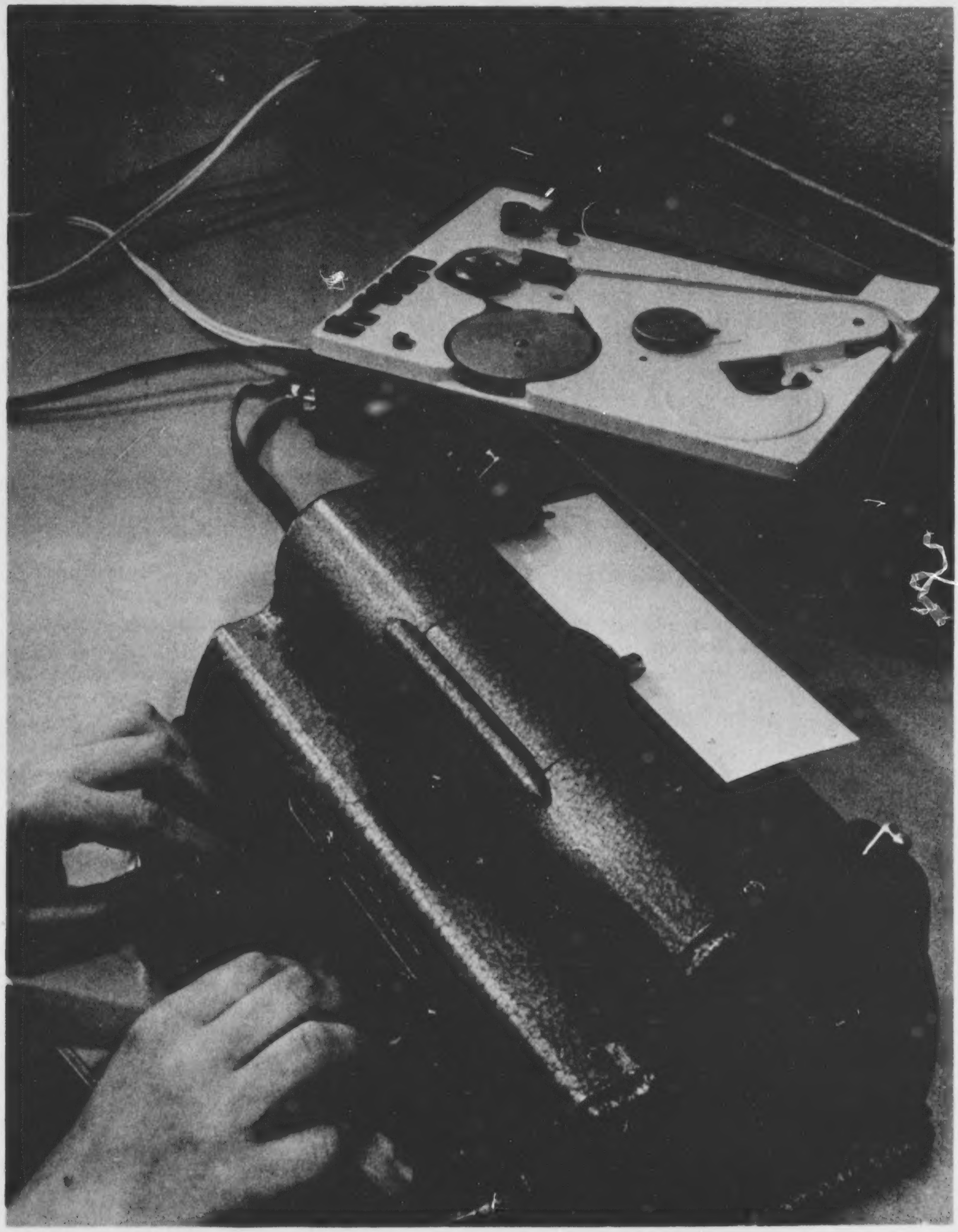

Fig. 2. Blind Reader with Argonne Braille Machine and Keyboard Device

Field testing has also been conducted to determine readers' reactions to the new system. Because of project funding restrictions, most of this testing focused on the reading machine. Nevertheless, the results warrant presentation, for they clearly demonstrate the feasibility of the system. Indeed, the most successful participants were able to read comfortably on the machine at their normally high reading speeds with no more than a few minutes of prior instruction. The results also indicate the possibility that the machines may improve reading speed; the long-term participants, for instance, tended to raise their reading rates significantly. Finally, information about the durability of belts and other components and evaluations of the system have been obtained to guide future decisions. Writing as part of the system has also been successfully demonstrated.

Fifty-one persons (not including approximately 50 others who tried the equipment at brief demonstrations) worked with the machines for periods ranging from 10 minutes to over 150 hours. These participants fall into three broad categories:

1. People known personally to the project staff and selected for their keen observation and ability to communicate experiences. These were mostly young adults, good braille readers, and persons of at least moderate manual dexterity; most of them were able to use the equipment immediately when it was shown to them.

2. Students from the South Metropolitan Association of Schools, the Illinois Visually Handicapped Institute, the Missouri School for the Blind, and the Neighborhood Youth Corps at the Chicago Lighthouse, and several other volunteers. These individuals, who were mostly children and adolescents, were shown the equipment without prior screening. Thus, they

constitute a more average group. Furthermore, the data from this group are conservative, since little time was allowed for learning if an individual was unable to read at all on the machine in its lowest speed.

3. Experts and persons professionally interested in the system. All of these are legally blind and use braille themselves.

Basic identifying data were gathered for each participant, including education, braille reading experience, and attitude toward machines (see Table 1). Most subjects were also tested for reading speed.(2)

The participants were then shown the machines, informed of the purpose of the project, and permitted to try reading on the belt moving at the slowest machine speed (see Table 2). Forty-three of the participants were given continuous text to read. The remainder, mostly young children, who had difficulty reading continuous text, used spaced material; that is, each word in the text was separated from the next by several blank spaces. The length of the gap was varied from eight to sixteen spaces. Also, we tried spacing groups of words. All reading material, both continuous and spaced, was Grade II Braille.

If time permitted, subjects were also shown all the machine controls. In addition, the long-term participants (who used the equipment for more than four hours) checked out various machines to see if they were operating correctly. They also spent considerable time testing the clarity of the dots and the belt "background."

TABLE 1

Basic Identifying Data About Participants

Children

Subject	Sex	Education (Highest grade or degree)	Likes Reading	Total Books Read Last Year		Prefers Braille or Recorded Books	Likes Machines
				Braille	Recorded		
1	M	1	?	?		?	?
2	M	2	?	?		?	?
3	F	2	?	?		?	?
4	M	4	?	?		?	?
5	F	3	a lot	?		?	?
6	M	4	some	?		R	a lot
7	M	5	a lot	10	90	equal	a lot
8	M	5	a lot	6	3	no pref.	a lot
9	M	7	a lot	10	5	B	a lot
10	M	7	a lot	> 25	5	B	a lot
11	M	8	?	?			
12	M	8	a little	0	78	R	a lot
13	F	8	?	?			
14	M	8	a lot	> 10	> 10	equal	a lot
15	M	8	a lot	> 25	10	R	a lot
16	M	9	?	3	6	R	
17	M	9	?	0	100	R	a lot
18	F	10	?	?		?	?
19	F	10	a lot	10	4	B	some
20	M	10	some	?	> 3	B	a lot
21	M	10	some	3	0	B	some
22	M	10	some	0	3	R	a lot
23	F	11	some	10	5	B	some
24	M	11	a lot	4	0	R	some
25	F	12	some	1	> 9	R	a lot
26	M	12	a lot	5	3	B	some
27	F	12	a lot	10	1	B	a lot

TABLE 1 (continued)

Adults

Subject	Sex	Occupation	Education (Highest grade or degree)	Likes Reading	Total Books Read Last Year		Prefers Braille or Recorded Books	Likes Machines
					Braille	Recorded		
28	M	mathematician	PhD	--	--	--	--	--
29	F	law student	PhD	--	--	--	--	--
30	M	ed. director	PhD	a lot	much	--	B	?
31	F	teacher	MA	a lot	--	--	R	--
32	F	psychologist	PhD	--	--	--	--	--
33	M	student	grad. school	a lot	4	46	R	a lot
34	M	student	college-4th yr.	a lot	2	2	B	a little
35	F	psych. couns.	MA	a lot	20	30	B	a lot
36	M	piano tech.	college-3 yrs.	--	--	--	--	--
37	M	student	med. sec. train.	some	0	0	--	some
38	F	rehab. teacher	MA	--	--	--	--	--
39	M	computer prog.	--	--	--	--	B	--
40	M	voc. instr. for blind	--	--	1 (+40 mag)	5	B-tech.mat. R-leisure	--
41	M	couns./teach.for bld.	--	--	--	--	--	--
42	M	electrical engr.	--	--	--	--	--	a lot
43	M	student	college-3rd yr.	some	1	> 9	--	some
44	M	student	college-2nd yr.	a lot	--	--	B	a lot
45	F	teach.vis.hndcpd.	--	--	--	--	--	--
46	M	spec.voc.training	BA	a lot	15	> 85	B	some
47	M	student	H.S. Grad.	some	2	0	B	some
48	F	homemaker	--	--	--	--	--	--
49	F	teach.vis.hndcpd.	--	--	--	--	--	--
50	M	student	college-4th yr.	--	--	--	--	--
51	M	spec. machine reading research	MA	--	5	< 20	R	a lot

TABLE 2

Speed Equivalents

Speed	Characters Per Second	Approximate Words Per Minute*
1	5.3	71
2	6.9	92
3	8.5	113
4	10.6	141
5	13.3	177
6	16.4	219

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*Computed with 4.5 characters per word, including spaces and punctuation. Character counts, on several samples we have used, ranged from ~4.2-5.0 and may easily exceed this range.

Discussion

Table 3 shows braille reading data collected from 51 persons who have had experience with the Braille Machine.(3) Reading time refers to actual time spent reading the moving belt, exlcusive of time spent learning to operate the controls, loading tapes, discussing reactions, etc.

Approximately one-third of the subjects (whose page braille, Grade II reading speeds varied, for the adults from 27 to 218 wpm and for the children from 5 to 180 wpm) could read either immediately or very soon on the machine. Four of these could read almost immediately on the fastest machine speed. Most, however, increased their rates gradually; many were continuing to improve at the time their test sessions ended. All those who could read well on Speed 1 could also read many words on Speed 2, and at least half the words on Speed 3; indeed, after a short period, many subjects moved up to a faster speed on their own initiative. Four subjects were unable to read at all on the lowest machine speed, and two could read only scattered words.

Figure 3 shows the percentage of total time spent reading at each speed by five persons who had more than four hours of reading experience with the machines. The figure shows that the long-term participants devoted only a small percentage of the total reading time to the lower speeds (Speeds 1 and 2); the majority of their time was spent reading at a higher speed (Speeds 3 or 4).

Figure 4 shows reading speed plotted against reading time. It underscores the point that relatively rapid learning occurs. Moreover, it suggests that the speed on the machine tends to increase and eventually to exceed initially measured braille page; the advance proceeds as a surprising reading speed, by regular function of time (see graph, page II-A-13).

TABLE 3

Braille Reading Data of 51 Participants

Children

Subject	Age - Years	Braille Experience Years	Braille Speed Before Exposure to Machine	Total Machine Reading Time Hours	Machine Speed Reached	(Machine) Reading Aloud Words Correct (speeds 5 and 6 excluded)
1	6	0.5	5	1.2	1	3/4
2	7	2	27	1.3	1	1/3
3	7	2	26	1.2	1	1/3
4	9	4	55	0.5	1	3/10
5	10	4	90	1.0	1	1/2 (disturbs belt with finger movements)
6	9	4	22	0.7	1	1/8
7	10	5	105	7-	4 (6)	all, 1/5
8	11	5	55	1.5	1	1/2
9	12	6	86	2	1	4/5
10	13	6	85	0.5	1	3/5
11	13	?	90	11.75	2, 4	all, 1/5
12	13	7	55	1	1	4/5
13	13	7	120	1.2	1	3/4
14	16	10	-	0.5	1	1/5
15	13	7	? (failed comprehension test)	0.1	-	*
16	15	9	121	0.4	1	1/2
17	14	9	73	0.2	1	1/3
18	17	10	85	< 0.5	1, 4	4/5, 1/5
19	16	10	84	0.3	1	1/2 (disturbs belt with finger movements)
20	16	10	84	0.3	1	1/5
21	17	10	95	0.7	1	1/6
22	15	9	51	0.1	-	*
23	17	11	143	1.25	1, 2	4/5, > 1/2
24	17	10	-	0.5	1	1/5
25	18	12	143	11.5	4	all
26	17	11	180	1	1	4/5
27	17	10	72	0.1	-	*

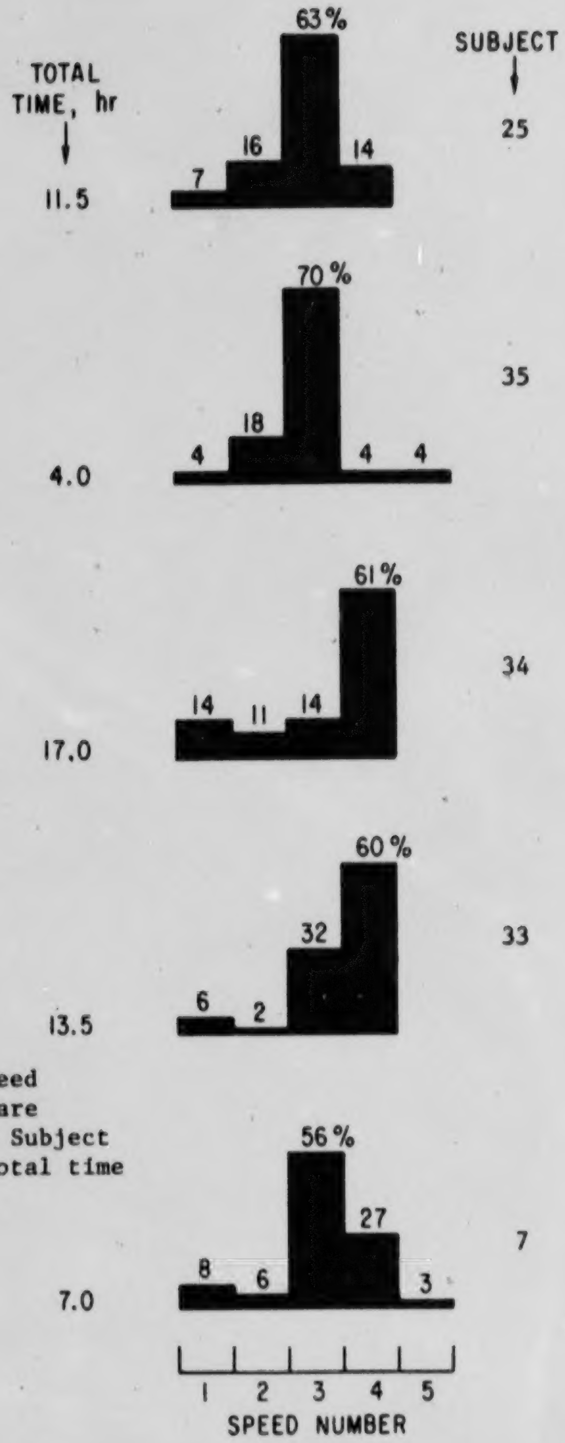
TABLE 3 (continued)

Adults

Subject	Age - Years	Braille Experience Years	Braille Speed Before Exposure to Machine	Total Machine Reading Time Hours	Machine Speed Reached	(Machine) Reading Aloud Words Correct (speeds 5 and 6 excluded)
28	44	?	185	1 -	6	all
29	?	?	? (high)	2-	6	all
30	55	?	? (high)	0.1	6	?
31	37	21	164	0.2	6	4/5
32	35	24	135	> 150	5 (6)	all (1/5)
33	24	18	156	13.5	5	all
34	22	14	203	17-	5	all
35	39	33	168	4-	4	all
36	24	18	218	6	4	all
37	20	13	164	0.5	4	3/4
38	31	25	?	0.2	2	all
39	42	?	100	0.3	2	1/2
40	55	49	?	0.1	1	3/4
41	?	?	?	0.2	1	2/3
42	?	?	?	0.2	1	1/2
43	20	14	146	0.5	1	1/2
44	19	12	105	0.3	1	1/2
45	?	?	?	0.2	1	1/3
46	28	19	111	0.3	1	1/4
47	18	13	94	0.5	1	1/4
48	40	?	27 ?	0.2	1	1/5
49	?	?	?	0.2	1	very few
50	?	?	38	0.7	1	very few
51	42	?	90	1.5	-	*

*hardly able to read on machine

+read spaced material only



Note: No data on speed distribution are available for Subject No. 4 (with total time 150 hrs.)

Fig. 3

Bar Graph Showing Proportion of Time Spent with Different Machine Speeds.

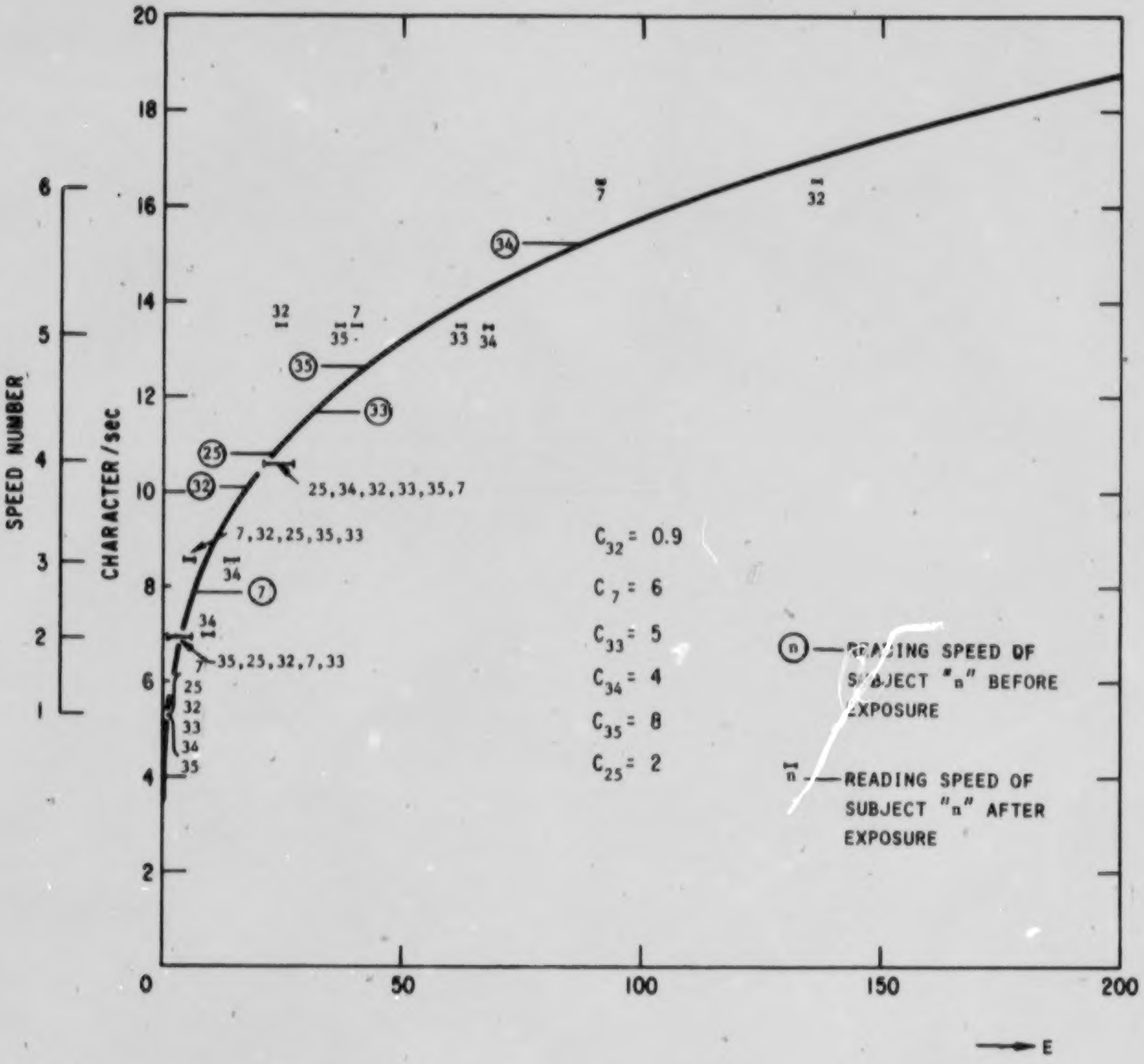


Fig. 4. Machine Reading Speed Achieved vs Machine Experience E. Experience (E) is presented as a product of Learning Time (h) and Learning Efficiency (C_n). *The second term turns out to be a characteristic constant* for a subject, which can be measured by the ratio of reading speed achieved divided by time used by subject "n".

Machine reading requires a moderately-light finger pressure. Some persons pressed so hard that the mechanism was disturbed and the braille characters were distorted. Other pressed so lightly on the belt that they could not keep the machine going. For these people, foot pedal control, which has recently been implemented, seems better than control of the belt movement by the reading fingers.

Some of the users found that their fingers lost sensitivity or became "numb" after ten to thirty minutes of continuous reading. Recovery from this "numbness" was rapid, generally within a few minutes, and reading was therefore not seriously inhibited. However, further study of the cause of this phenomenon and reader adaptation to it is warranted. Perhaps longer spacing between words or at the end of each sentence would provide sufficient breaks to eliminate the "numbness." We are experimenting to see if covering the reading finger with a plastic thimble will redce or eliminate this problem.

Some other users had difficulty because their fingers sweat, making it hard for the belt to pass smoothly under the fingertips.

A frequently-voiced comment was that the braille was "dim," "not raised enough," and that characters at the weld (i.e., the place where the belt ends are connected in fabrication) were sometimes distorted. Our impression is that motivation plays a major role in a person's ability to read with less than familiar or perfect materials.

Sensitivity of the machine was occasionally a problem. Several subjects especially the younger children, pressed, pushed, and pulled the belt to such an extent while reading that the machine mispunched and the belt made errors.

Users found the machine controls easy to operate. The rewind, fast forward, and on-off switches presented few problems. Loading the tape, on the other hand, was difficult for some persons. One subject commented that it was complex and sometimes frustrating.

Response was mixed regarding the clicking sound of the Braille Machine. Some students felt that this might be disturbing in a classroom or dormitory room, thus limiting machine use to private study only.

The writing function of the machine did not pose any serious problems or cause objections when machines were used in this mode by subjects. However, the only persons who used machines extensively for writing (mostly preparing special test tapes and the like) were volunteer transcribers and - to a lesser degree - one of the authors; commentary was satisfactory. No systematic results were obtained so far.

The Braille Machine is relatively lightweight and compact. It should, however, be carried in a padded case; and a separate power supply, about the size of a cigar box, is also needed. The machine thus is less portable than a cassette player or single braille volume but more portable than a large braille book consisting of several volumes. A few subjects felt that the equipment still was unwieldy. Commented one girl: "I like to take my book to the beauty shop or on the bus, and you can't carry this machine around and do 'anything'..."

User reaction to the new system varied widely. Stated one reader, "I am tremendously enthusiastic and hopeful...the machine offers a light, flexible approach to reading..." Some subjects were excited by the machine's potential: "This machine has great potential for keeping books in a small place." "The machine would be good for working on braille speed reading." Where the reaction was less enthusiastic ("At this point I wouldn't buy one, but they're on the right track"), further development of the system seems indicated. Three areas, in particular, need improvement for general user acceptability: machine reliability, method of threading tape, and prominence of dots.(5)

CONCLUSIONS

In conclusion, we submit the following observations:

1) Almost ten percent of the sample found the machines immediately acceptable and from the start used them skillfully even at the higher speeds.

2) Another group, four-fifths of the sample, experienced at least some difficulties in reading with the machine but could read more or less well from the start, at the very least some words at the slowest speed. Those people who continued reading for several hours improved considerably; their reading speed increased along what appears to be a regular curve towards a maximum in the range of speed typical of the group mentioned in 1). It is especially noteworthy that the reading speed of some of the participants surpassed their individual scores measured with regular braille before exposure to the new system.

3) The remainder of the sample (roughly 10 percent), who did not demonstrate a clear ability to read at Speed 1 after a short exposure, were not followed up, because our resources and the pressure to collect necessary data for development of the equipment did not allow us to develop their skills over longer periods. Some of this group would probably have responded to such efforts.

4) The learning curve illustrated in Fig. 4 suggests a causal relationship between reading steadily moving braille characters and resulting reading speed improvements.

5) The learning curve suggests that the new system could be used to develop braille reading skills.

All students ranging in age from six to eighteen could read spaced words metered on the machine,(6) and approximately half could read some continuous text.

Even very young children demonstrated that they can decipher some braille passing under their fingers at a rate of approximately five characters per second.

One student progressed from reading spaced to continuous material, and another student read spaced phrases as well as singly-spaced words after some practice. We believe several more who were improving in their ability to handle spaced material would have made this shift with further practice. Spaced material, then, seems promising as a training format; it has been with beginners and with others who have difficulty reading on the machine.

6) At least four factors seem to account for ability to read on the machine: prior braille reading speed, finger sensitivity, motivation, and practice.

References and Notes

1. "Braille Reading Machine", See SCIENCE, Oct. 7, 1966, No. 3745; Work performed under the auspices of the U. S. Department of HEW, Office of Education, Bureau for the Education of the Handicapped.

2. Most reading speed of participants were measured using a selection from The American Adventure, by K. Bailey et al., Field Ed. Publications, Inc., San Francisco, 1970 (7th grade level on Fry Readability Index). The younger children were tested using an unfamiliar passage in their basic reader.

3. Designs for a self-threading tape mechanism exist but are not yet incorporated into the system.

4. A separate report will cover an investigation of the influential variables leading to acceptance of dots and methods to optimize this acceptance by modification of the dots.

5. Spaced material was not tried with the six early subjects listed in Table 3 as non-readers.

BRAILLE MACHINE EXPERIENCE

Date: 6-21-73

Subject: K.G.

Sex: F

Age:

Blindness: Believed to be congenital

Education: Ph.D.

Braille Status: Exceptionally competent, constant use, up to 265 wpm on machine

Braille Machine Experience: $\lesssim$ 2 hours(1)

Background: Education director of correspondence school - presently law student

Subjects Remarks:

"As a new user of the machine, I am tremendously enthusiastic and hopeful. Though I have long enjoyed reading the massive volumes in which the traditional braille book is presented, I have repeatedly wished that braille could be more compact, more available, more economical. The Argonne machine seems to be answer. Besides offering a light flexible approach to reading, it has the advantage of being a writing device, especially useful for marginal notes. If only I had such a tool to help with my first year of law school this fall.

"Not only as a user, but also as a student of braille reading, I am optimistic about what the Argonne machine will do. When readers have built up a good speed through training with the dial control, they will be able to handle braille materials at a rate far faster than that of the normal recording. The indexing system of the machine will provide flexibility, too; and the net result should be a greater and happier utilization of braille. Much as I have benefited from recordings, I am convinced that nothing can replace the experience of reading and rereading for oneself.

---

(1) Subject read, apparently effortlessly, on the machine after only a very few minutes of demonstration and practice. She quickly used all the controls by herself and operated the machine successfully up to its maximal speed.

"From my own experience, I feel that the use of the Argonne device can be readily learned and that technical problems can be overcome. For example, I believe that readers can be taught to insert the open-reel tapes without undue difficulty and that the transition to cassettes would be unwise. So far I have not noticed the "shadows" mentioned by other readers. I do believe that the belts should be replaced frequently, since they tend to present "ghost dots" after numerous recyclings: but since the machine will be designed with a readily accessible compartment for the belt, the reader can easily replace the belt as often as he wishes. I have observed some problems in the spacing and accuracy of the braille; however, I am confident that these also can be worked out."

BRAILLE MACHINE EXPERIENCE

Date:	7/10/75
Subject:	P.G.
Sex:	M
Age:	24
Blindness:	Congenital
Education:	three years of college
Braille Status:	Uses braille extensively; over 200 w.p.m.
Braille Machine Experience:	10 hrs, spread over several years
Background:	highly mobile, competent, technically inclined, well read

Subject Remarks:

"The machines approach production status. I would probably need a little more practice before I would feel completely relaxed; I refer—as an example—to reading strictly for recreation. But I do not anticipate any trouble reading at this state once the problem with the welds is completely overcome. (I would recommend the latter as first priority, now that other things are pretty good.)"

(Concerning the weld, subject commented that it was much improved in the last sample he tested and that sometimes he now can disregard the weld; but frequently the passing weld still makes him lose one or even several words.)[1]

"The feel of the belt in general is definitely different from normal braille but not badly so; I'd say about between Brailon- and paper-based material; I like it better than thermoform. I can read (even with the weld throwing fairly fluently, but I am sure I'd stumble (for instance) when reading aloud. Speed 5[1] is - at present - too fast for me. I am, of course, aware of the sounds of the machine, but they do not bother me in any way."

---

[1] Welds have, since subject tested the machine for the last time, been made even less conspicuous.

---

[1] This subject was (perhaps because of his large hands?) more aware of the weld than most. We consider, therefore, his maximum speed score as preliminary (see his remarks above about "losing words").

BRAILLE MACHINE EXPERIENCE

Date:	8/14/74
Subject:	L.W.
Sex:	M
Age:	44
Blindness:	Believed to be congenital
Education:	Ph.D. (Math)
Braille Status:	Exceptionally competent; constant use, up to 265 w.p.m. on machine
Braille Machine Experience:	Several short (minutes at a time) exposures, advising and consulting with the project staff.
Background:	Staff ANL, Applied Math Division

Subject Remarks:

(Does not move his hands with the belt at all, which differs from his usual "braille movement". When we suggested that he may want to be less rigid, moves his hand freely up- and downstream.)

"...no problem; but in the long run it would probably be best to keep hands still and process incomplete information intellectually rather than to catch missed portions. To read at constant speed (on the machine) is a different, more 'global' game, more like reading phrases rather than words."

(After reading silently for about 5 minutes at Speed one, i.e., at 78 w.p.m., subject switches speeds up himself, all the way to Speed six = 265 w.p.m.)

"There is occasionally a character missing--"

(The machine drops one character every time it is stopped and re-started with the trigger switch.)

"--Aha; inconsequential. --At Speed five (i.e., 208 w.p.m.) I get still nearly 100% of the meaning; at Speed six (i.e., 265 w.p.m.) I have still high comprehension but not any more 100%.

"The bar switch and overload slide action is quite satisfactory.

"Texture of belt is quite satisfactory; probably for most users more acceptable than 'Solid Dot'. Belt on one machine is 'noisier' than the one on the second sample.[1]

"Error rate on Little Prince very low, on The Gods Themselves quite tolerable."

(This session lasted about one hour.)

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[1] Belt had been used harder before this test.

BRAILLE MACHINE EXPERIENCE

Date: 8/30/75
Subject: V.K.
Sex: M
Age: 18
Blindness: Congenitally blind
Education: High school senior
Braille Status: Uses braille extensively at 130 w.p.m.
Braille Machine Experience: 50 hours
Background: Good student, college bound (math and science)

Subject Remarks:

"I think that this machine could serve a substantial number of visually imparied students very well. I don't say all students because it wouldn't be of much value or assistance to those students taking math or science since, for example, work with matrices would not be possible because the rows of numbers could not be placed under each other. The student must also be a reasonably good braille reader and in courses involving diagrams, the book would be better off done in braille since they would otherwise have to be done separately.[1] The students to whom this braille machine would be very useful would be those who are taking courses such as literature or history in which a lot of straight reading is involved.

"One problem to me about this machine seems to be that a book available for this machine can only be read on this machine so that should the machine stop working, the book wouldn't be of much use unless a spare one is available. This of course is similar to a tape recorder, the only difference being that an extra tape recorder is easier to get a hold of or the broken one repaired easier.

---

[1] We feel that books requiring illustrations, tables, equations, etc. should also be prepared on tapes; a supplement--on a few sheets of paper--for the 2-dimensional material would be used (and the speed, bulk, and cost advantages would be retained).

"The machine, if a student can afford it, would be of benefit only if its chances of breaking down and cost of maintenance are minimal, since if a student is at a college he will lose valuable time if his machine breaks down in getting it repaired if that can be done at all.

"I would like to have this machine since it no doubt speeds up the reading process, if some organization helped in obtaining it, provided a quick repair service and if a sufficient quantity of non-brailled books were available; I would only choose this form of reading over braille if the repair service was excellent, with spare machines available during time of repair.

"Improvements could be made on the machine by making it simpler, for example in terms of putting in and taking out the tape, finding your place on the tape, that is, making it easier to locate any and all pages by some system other than the trial and error one.[1] Also the power supply should be eliminated or at least simplified.[2] The final--and probably the most important as far as adaptation for at least a few blind students--would be of making the control on the right rather than the left as far as the belt is concerned, which would make reading missed letters or words easier. In my opinion it would be too much of a problem for a blind student to carry the power supply, braille machine and braille writer around[1] so that the elimination of the power supply or at least its attachment to the machine or building it in would be much better even though the machine might become heavier, thicker or wider. This would make handling easier.

---

[1] Subject did work with a tape which did not have indexing marks recorded on it. The machine is equipped with an automatic search feature which can position the tape selectively, for instance, at a selected page number.

[2] Subject suggests apparently integrating the power supply with the machine. We think that he is mistaken and would revise his opinion when he would experience a heavier and bulkier machine.

"In my particular case, there will be three students in my room at college, which means that if I have to read--let's say at night, they may be disturbed by the clicking sound, and if I have to go somewhere else with the machine, again the inconvenience of carrying at least three things appears, and this could also hold if the teacher gave some extra time to read in class where, in that case, the class would be disturbed.[2]

"The advantages of the Braille Machine are obvious: It speeds up the rating, it eliminates the need of getting a different volume of a bulky book every second day, and it would make the storage, carrying and production of braille material easier and probably cheaper.

"My overall view and opinion of the Braille Machine is that it is very useful and has a great potential for usefulness to many blind persons. I myself would like to own it if it were cheap enough, if there was someone knowledgeable about it as far as repairs go, if there was an extra one available during repairs and also if there was a big enough quantity of books available on this type of tape. There would also have to be a place available where it could be used since it would be inconvenient to others[1] and since it wouldn't be something that would be used in class because an electrical outlet has to be available along with a desk for the power supply.[2] Also this is not something that can be carried around in college halls.[3] I particularly like the machine because it takes a certain number of print pages and puts them on a little tape which is easily carried instead of on a big set of braille books."

---

[1] The power supply is a small box carried easily on a shoulder strap; the "braille writer" (to operate the machine as a "write on tape" device which allows to make "margin notes" on a book tape or to write on a separate tape) is a pocket size keyboard; the machine itself weighs about 8 pounds and fits easily into a briefcase, together with several books on tape and other utensils.

[2] The "clicking" or "chirping" sound level of the machine is very much lower than that of a portable typewriter.

---

[1] The "inconvenience to others" --if any--is probably limited to a shared bedroom (see note 2, p. II-B-9).

[2] The device can be operated for 1-2 hours on batteries in the power supply; also operation from an outlet (total power required is about 10 watts) should be available in many cases.

[3] Why not? (See note 1, p. II-B-9.)

BRAILLE MACHINE EXPERIENCE

Date:	10-16-75
Subject:	J.D.
Sex:	M
Age:	22
Blindness:	Congenital
Education:	Senior in college
Braille Status:	Fast reader, tested 203 w.p.m. page reading
Braille Machine Experience:	~ 17 hours
Background:	Part-time musician

Subject's Remarks:

"It's been interesting--fun and interesting to do this.

"Today's belts were 'horrible'; I still can't read beyond Speed three today--and last week I was up to 5 and looking forward to 6.

"Is there really a need for something like this, or are there more important things to worry about? We have the braille book system, and that, at least right now, is superior in quality to this.

"In order to make this commercially available the braille must be raised in comparison to the braille on paper or plastic paper. What I mean is that the braille is not raised enough on the belt as compared to reading plastic paper.

"Using the machine is not a difficult task in itself--rewinding it, fast forwarding it, using note and book--it's all very simple.

"I believe that the machine can only be used in private study and not among a group of people. I think it would be too disturbing; you couldn't take this thing to class.

"The area where the tape is threaded should be a little larger; perhaps some of the plastic might be cut away."

BRAILLE MACHINE EXPERIENCE

Date: 11-5-75

Subject: W.H.

Sex: M

Age: 24

Blindness: Congenital

Education: Graduate student (History major)

Braille Status: Uses braille extensively at $\sim$ 200 w.p.m.

Braille Machine Experience: $\lesssim$ 10 hours

Background: Well read, competent student

Subject's Remarks:

"I have been using the Braille Machine, at this writing, for about ten hours. This is, of course, a very short period of time. Even so it seems to me that the machine has great potential.

"Looking at the machine from a viewpoint of a student, who probably will have done most of his studying by means of recordings, it seems to me that the machine would make studying from braille feasible. At present it requires too much space to produce and store large numbers of brailled books. The braille machine would reduce the size of the material.

"A second advantage is that instead of listening to recorded material, a student who uses the machines would have the material right at his fingertips. I personally always found that there was something to be gained from being able to 'read' rather than listen to the material.

"The machine will probably be most useful in reading written material, for study purposes. I don't think... I suspect that it was not intended to reproduce material requiring spacial relationships (graphs and schematic diagrams, for example). The machine's value for straight reading outweighs by a margin this disadvantage.

"In conclusion I believe that there is a need for a machine of this type. It can serve a useful purpose. I hope that work continues on it and that progress will continue."

Notes:

We observed that subject reads with his two index fingers side by side and contacting each other, and asked whether, and if so why, he prefers this method. He feels that while he gets his information predominantly from the left index finger the right one "reinforces" the information (his choice of words). We asked what he means by "dominance" of the left hand in his reading. He thinks that he reads most of the time with the left hand and that only the last characters of each line are read by the right hand (while the left goes back to the left margin and onto the next line).* We asked how he can tell that the left hand is "dominant," if the right hand alone does read successfully part of the text (even if it is a small portion of the whole material). He answered: "Yes, but it is slower (even though no less reliable); I have tried to touch the belt with either the right or the left hand alone, and I can read both ways. But I have to switch back to a low speed to be able to do it with the right hand."

---

* His teacher taught him that this is "the correct way; perhaps it is preferable to me now only because of habit."

BRAILLE MACHINE EXPERIENCE

Date: 9-27-76

Subject: P.K.

Sex: M

Age: 10

Blindness: Total, congenital

Education: 5th grade

Braille Status: Reads 105 w.p.m. (test sheet average ∿ 4.8 char/word)

Braille Machine Experience: ∿ 7 hours[1]

Subject's Remarks:[2]

"That braille is a little pressed down, a little hard to read." (after 15 minutes)

"This is fun, even if it is hard to read."

(Trying to increase his speed) "I am sort of nervous...afraid I won't do well."

(at Speed 3) "I think I am catching the meaning of the book, now. I think Speed 3 suits me; until I learn to read a little faster, Speed 4 is a little too fast for me."

(4th session) "I notice my fingers are not shaking anymore."[3]

---

[1] Actual reading time; ∿ 3 hours spent on instruction in use of controls, loading tape, etc; could at the end of period perform all of these operations (or at least struggle through them) by himself.

[2] As noted by the project staff.

[3] ∿ 110 words per minute.

"I really like these machines...you do not have to move your fingers up and down" (reads now on Speed 4 also).[4]

"Occasionally, I go back to Speed 2[5] so that I do not miss anything there.

"I like the foot pedal rather than finger (pressure) control...though I like to sometimes use one or the other.

"There is a problem...the tapes might tangle or break. If the machine bust you would have to send them to some place...If a braille book tears, if it's not too bad, you can still read it."

(In regard to loading a tape onto the machine) "It is hard to find your place."

---

[4] They tended to shake even when reading conventional braille.

[5] ~ 140 and 90 words per minute, respectively.

BRAILLE MACHINE EXPERIENCE

Date:	9-28-76
Subject:	G. DT.
Sex:	M
Age:	55
Blindness:	Total, congenital
Education:	Ph.D. & Dr. Juris
Braille Status:	Obviously superior
Braille Machine Experience:	∿ 15 minutes
Background:	Director of Regional School & Institute for the Blind

Subject's Remarks (through interpreter):

"I learned braille at 6 years of age. I am an avid reader. I never tested my speed. Do I read faster silently than I can speak? Certainly!

"In Italy, also, interest in braille is diminishing, first because of the scarcity of material (in braille) and second because (tape) recordings are now easier to get (and less expensive). Furthermore, congenitally blind are becoming fewer. The optimum condition for learning braille is to learn it when very young and not to have additional handicaps. I feel the project that is in course at this center serves to re-create the faith in braille...that since 1825 conquered the whole world (but will disappear) if not reinforced with advanced technology like the one that is going on at this location. This machine is of an absolute efficiency...I am asking how soon we can get it in Italy?"[1]

---

[1] Subject knows only some words in English (and no English braille contractions). He nevertheless picked up immediately many words in Speeds #1 and #2 and is certain that if the text was Italian he could read it completely and easily even at Speed #6.

THREE CASE HISTORIES

Three case studies of individuals experiences with the Braille Machines are detailed below to illustrate the testing procedure and the various reactions of the participants.

P.K.

Peter is ten years old, blind, in a fifth grade braille class at a public school. He learned to read braille when he started school, "loves to read," and has no preference between braille and recorded material. He stated that he had finished "almost the whole shelf" (over one hundred books) in his room and in the past year had read more than ten books in braille. His reading speed is ∿ 105 w.p.m.

Peter spent eight sessions with the project staff, from July 27 to September 1, 1976. Sessions averaged two hours, with periods of reading alternating with experimentation on the machine controls and commenting on the system.

During the first session, after some brief comments by the investigator about the purpose and operation of the Braille Machine, Peter was permitted to read on the moving belt. The text was The Little Prince (which he had read before in recorded form). Resting his left wrist on the speed control knob, Peter placed his arm at an angle such that his left index finger was almost parallel with the belt direction (i.e., elbow way out to the left). Only this finger was used to read, though sometimes he put his right hand on the belt. Peter was able to decipher about two-thirds of the words at Speed 1 in this fashion. Asked his reaction to machine reading, he replied, "That braille's a little pressed down--it's a little hard to read." Nevertheless, after about fifteen minutes he commented, "This is fun, even though it is hard."

Peter's use of the machine was complicated by the shaking of his fingers. His left index finger, in particular, actually bounced the belt up and down. However, he did not seem disturbed by this; he said that his fingers usually shake when he reads.

During the second session, the investigator's attention was primarily directed towards other persons in the room. Consequently, Peter's reading was limited to 15 minutes, again at Speed 1 using The Little Prince.

For the third session, two new texts, which Peter had not read before, were introduced. Peter read first on Speed 1, using A Witch's Garden. His ability to read varied: at times he could read strings of six or seven words, at other times just a word or two--not enough to get the meaning of the book. He did detect frequent mistakes on the belt, but the investigator was unsure whether these were from his arm touching the pinch wheel (which he admitted was happening sometimes) or from the shaking of his finger.

After a brief rest (Peter had complained that his arm was tired), he tried reading The American Indian on Speed 2. Despite his admitted nervousness ("I'm afraid I won't do well"), he was able, after five minutes, to move up to Speed 3 and then, almost immediately, to Speed 4. He found he could read at all four rates but preferred Speed 3 until he "learned to read a little faster." Speed 5 he felt was too fast; he could catch only a word here and there.

Peter spent a total of one hour reading (spaced over a two-hour period): 20 minutes on Speed 1; 5 minutes on Speed 2; and 30 minutes on Speed 3, including approximately 2 minutes trial on Speeds 4 and 5. By the end of the session, he could understand most of the material on Speed 3, despite missing an occasional word or phrase.

Other changes were also noticeable: his fingers were not shaking, and he said he was not tired. (This may have been due in part to his new reading position: his thumb now went "around" the speed control instead of his wrist on top of it, and his right index finger was placed against his left.) He understood readily the various controls he was shown, including the speed control and on-off switch, which he operated himself.

Peter's interest in the machine continued in the fourth session. "I like these machines," he exclaimed. "You don't have to move your fingers--up and down, up and down--all the time." After asking several times about rewinding the tape to read something over, he was shown how to rewind a few turns by hand. The foot pedal, an alternate method of starting and stopping the belt, was also demonstrated; he commented that he might like "to change off," using fingers sometimes and foot pedal at others.

Peter spent about one hour reading The American Indian at Speed 3. As in the previous sessions, he was easily distracted; he would read for a few minutes, then stop, preferring to talk. At times, therefore, the investigator found it beneficial to leave the room for short periods to allow him to read without distraction.

Reading during the fifth session was hampered somewhat by the high temperature of the room (above 80 degrees) and faulty air conditioning: Peter complained that his fingers were sticking to the belt. Perhaps because of this, his reading pattern varied somewhat. Speeds 5 and 6 were still too fast; and, while he read most of the hour at Speed 3, he slowed down for about fifteen minutes to Speeds 2 and 1 so he "wouldn't miss anything." Beginning with this session, too, he chose to use the foot pedal rather than hand controls.

Peter's interest in the machine continued. He discovered that it would punch a character or two whenever it was turned on or off, and he tried to see if he could get it to punch a character with the pinch wheel out.

For the first time the investigator demonstrated how to lead the tape. Peter initiated a game that the tape was a monorail going aroung houses (the guides) through a canyon (a slot). On his own, he remembered the path fairly well but in two tries could not get the tape into the path: "It's so hard to find your place." Later he tried again and on the second attempt threaded the tape correctly, up to the last guide.

Practice with loading the tape was stressed during the last session. Problems kept arising: first the pin broke off the end of one tape, and then the drive belt slipped off when Peter moved it accidentally. In two tries, taking about ten minutes, Peter could not thread the tape, primarily because it kept popping out of the track. On the third trial, however, he threaded it successfully through the last guide.

His reading was also disturbed by intermittent mistakes on the belt. The investigator felt that these mistakes resulted from Peter's fingers shaking, but this could not be confirmed in all cases since her hand was not always on the belt at the moment the mistake occurred. Peter also occasionally missed proper nouns and would go back to reread them. This, too, he found frustrating: since he could not press lightly enough to read while the belt was stationary, he had to go through the rewind and fast-forward process, often overshooting his place. Despite all these problems, however, Peter read without serious difficulty for thirty minutes, including fifteen minutes each at Speeds 3 and 4. At the end of the session, he read aloud for his mother, missing perhaps 1 word in 8.

At the end of the participation, Peter was tested on all 6 speeds for one minute each, reading aloud as many words as he could manage. The percentage of words read correctly were for Speeds 1 to 6 respectively 91, 95, 92, 90, 68 and 22. At the two highest speeds (∿ 180 and 220 w.p.m.) difficulty in pronunciation must have been a factor in the decrease in percentages, and we conclude that Peter read essentialy all words up to and including Speed 5.

The investigator chose to exploit Peter's interest in machines in Session 6 by spending considerable time demonstrating the operation of the equipment. Peter helped unscrew the lid from the machine carrying case and successfully removed a tape from the machine three times with minimal coaching. He also learned how to use fast forward and how to rewind using the push button control. (Previously he had done it by manually turning the reel.) Though he did not cause any tangling of the tapes or breakdown of the machine, he was a little disturbed by the possibility:

> There's a problem with tapes--the tapes might tangle or break; the machines might break . . .If the machines bust you would have to send them to some place a long way away and it might take a long time to fix. If the braille book tears, if it isn't too bad you can still read it. . .The machine breaking--that's one disadvantage.

One difficulty Peter experienced was finding his place when he used the rewind control to reread the material; he had a tendency to overshoot the mark. Peter also found it hard to lift his finger quickly enough to stop the belt when he wished to show the investigator something, e.g., a particular word on the belt.

On the other hand, Peter read with greater facility this session. After reading The American Indian on Speed 3 for about thirty minutes, he commented that it "was getting a little slow" and spontaneously chose to go to Speed 4, on which he read successfully for fifteen minutes.

During the seventh session, Peter continued to read on Speed 4. In passages from The American Indian and The Little Prince, he got 3/4 to 4/5 of the words when he was asked to read aloud, though somewhat irregularly, reading a sentence or two and then missing several words. He still preferred the foot pedal to manual belt control and could plug in the pedal himself. He operated the fast backward and forward, the speed control, and the on-off switch well and was able to remove the tape from the machine correctly after being reminded how to disconnect the pin from the take-up spindle.

M.M.

This participant is 39 years of age and has a Masters Degree in guidance counseling. Totally blind since early childhood, she learned braille at age 6, reads a lot, and prefers braille to recordings because she can skim braille more easily. It may be important to note that she has rheumatoid arthritis, which causes some cramps in her hands and fingers, for instance, when she uses a typewriter (even though it does not interfere with reading regular braille).

In the first session she could read immediately on a stationary belt and on a belt moving at Speed 1. After a few minutes, she could also use Speed 2, but Speed 3 seemed too fast for her. ("I miss a lot of words.")

She commented that Speed 2 appeared slower than her normal reading rate (on regular braille): "I think if the dots were sharper I could read on the third speed." She got, however, at least 3/4ths of the words even on Speed 4 (and isolated words on Speed 5); the "steady stream" of braille did not bother her.

After ∿ 15 minutes of reading, missed words occurred more frequently. By the end of ∿ 1/2 hour of continuous reading, she observed that her fingers were getting numb as if they were losing their sense of touch, and her hands cramped from holding the fingers still.

After taking the machine home and reading ∿ 3 hours (63 pages of Arthur Rubinstein), mostly on Speed 3, she concluded she did not like the machine. (Earlier she had commented that she might get one if the dots were "sharper.") In spite of her complaints about cramping, unsharp dots, and difficulty of reading proper names, etc., at high speed, she estimated that she had missed perhaps only one word in 25-30 (and did "not go back because I can understand anyway") and volunteered an evaluation of the book she had read (she liked it).

When she tried (at Speed 2) control of the belt with a foot pedal and a different arm position (machine on her lap rather than on the table), she "felt better" about the system. After about 5 minutes on Speed 2, she commented, "I'm reading every word now." Switching to Speed 3, she "missed a word here and there" and then on Speed 4 "got almost everything;" she was confident that "with practice" she could do even better.

The participant could thread the tape herself without trouble but felt that most blind people were less dexterous and could not do it by themselves.

After a total exposure of ~ 4 hours of reading plus some explanation and discussion, the participant summed up her reaction as follows:

> It would take a lot of convincing to get me to use this rather than a braille book or magazine because it isn't portable. And I can't read for more than a half hour at a time, and I read for hours and hours... I don't really think I'd like reading on this machine, but I don't know if that is just because you're used to what you've got and resist change. If the quality of braille didn't improve, I would read very little braille if I had to use this machine.

P.B.

One of the authors (the test coordinator) has had more experience with the Braille Machine than any other blind individual. We present here a first person account of her experience and comments. We wish to alert the reader to the fact that her attidudes are likely to be influenced by her professional association with the project.

"For the past twenty months I have been on the staff of the Argonne Braille Project. During that period I have had almost daily contact with the Braille Machine - reading, testing belts and equipment, and instructing and supervising others in their use. My conservative estimate is that I have read text materials for over 150 hours, in addition to spending many more hours in testing equipment. During this time I have read parts of nine books, mostly fiction but also some nonfiction, and have read one entire book. In addition, I have accumulated about four hours of experience writing on the machines with a Perkins Brailler, modified (electronically) for this purpose.

"When I was introduced to the machines I could immediately read most words on Speed 1. Very soon I tried Speed 2 and could read on it as well as on Speed 1. In the beginning, I was pessimistic about my ability to read quickly and felt disturbed if I missed letters or words; although I tried Speeds 3 and 4 and could get a number of words at these speeds, I continued to read for a time at Speed 2.

"Gradually, my confidence, ability, and willingness to rely on context increased. I began to read more often at Speed 3 and then at Speed 4. This change was not completely linear. That is, I might read on Speed 4 on a day I felt particularly alert but drop back to Speed 3 when I became tired or when I felt less ambitious.

"It became apparent that different speeds were comfortable depending on the material. I could read The Little Prince with relative ease on Speed 5, while it was easier to read The Gods Themselves, with its longer words and greater number of proper nouns, at Speed 4. After about thirty hours I was regularly reading on Speed 4 but might read on Speed 5 if the material was easy or if I felt particularly alert; whenever a belt deteriorated, I read on Speed 3. I have maintained this level essentially up to the present time. During the last two months, however, I have found that I can read strings of four to six words at Speed 6, the top speed of the machine. I now use this ability to help me find my place or to skim material for a particular word or passage.

"The process of learning to read on the machine requires some adjustment of habits. Some words appear different as they pass under my fingertips compared to the impressions I get when I move my fingers over a braille page. I notice this difference especially with long words where, for example, an "oo" may stand out prominently. I do not know what causes this difference. My impression is that particular words become more easily recognizable with experience on the machine.

"For years I have had the habit (frowned upon by reading speed experts) of rereading certain words I missed. The inconvenience of rewinding the tape to catch a missed word has caused me to give up this habit. At first I felt dissatisfied with missing words, but the new procedure now seems comfortable. Sometimes when I miss proper nouns, such as the names of characters in a novel, I still go back and reread them. My experience (and that of others I have observed) is that such unfamiliar proper nouns are more often missed in machine reading than are other words.

"For quite some time after I began to use the machine, I felt I needed to focus or concentrate more than was necessary in braille page reading. Reading with the machine seemed somehow 'farther away.' I am not sure whether this "distant" feeling results from "noise" or from indistinct dots, the presence of the machine, the inactivity of my fingers, or some other cause. My initial reaction was that I might read on this machine something that was necessary, but I did not imagine becoming involved with the reading material. I remember the first time I became really absorbed in a a passage and did not want to stop; it surprised me. Although I still occasionally experience this 'far away' feeling, I now am usually involved in what I am reading.

"One problem is that the sensitivity of my fingers decrease after a period of reading, sometimes as short as ten minutes. They may feel numb and slightly uncomfortable. When this loss of sensitivity occurs, I start to miss dots in characters and thus to misread words. Raising my finger from the belt for a few seconds is helpful, but after about twenty-five minutes of uninterrupted reading I need to stop for a few minutes to regain sharp finger sensation.

"From the beginning I have found the controls easy to operate. While some users prefer the foot pedal, I prefer the finger control to stop and start the belt: I like the immediacy and simplicity of deciding to read, placing the fingers on the belt, and starting. However, I find the foot pedal useful for reading material from a stationary belt. For example, the foot pedal allows me to read some numbers from the belt, write them down, and then return to the belt to read more numbers without fear of losing the data by pressing my fingers too hard and starting the belt movement unintentionally.

"Another problem on the Braille Machine, as with any open reel or casette equipment, is locating a particular place in the tape. I often feel frustrated trying to find the place where I stopped reading earlier. This problem will be reduced when the indexing feature of the machine is fully implemented in the working system."

FIELD STUDY PLAN FOR THE ARGONNE BRAILLE MACHINE - A. Grunwald and P. Biesemeier

Introduction

The field study described in the following paragraphs is designed to test the applicability of the Argonne Braille Machine as a reading device to augment or possibly partly supplement standard page braille material for the blind. A variety of parameters will be tested by studying data accumulated from the experience of approximately 40 blind persons.

Access to the written word is a vital factor in the ability of blind individuals to compete successfully in education and employment. Braille, recorded material, sighted readers and reading aids each have a place in helping this need. Each of these methods of access to material serves a necessary and unique function.

There are, at present, major drawbacks in the way in which braille material is produced. Because braille material is very bulky, it presents serious storage problems in libraries, schools, places of employment, and people's homes. For example, the American Vest Pocket Dictionary edited by Stein requires more than 1 1/2 cubic feet of storage space. This bulk necessarily limits the amount of reference material a blind person can obtain and keep. This can be a serious employment or study problem. In addition, the bulkiness and weight of braille material makes it an expensive commodity for the post office to ship from place to place.

Furthermore, production cost of braille material is high and rising, making braille expensive for libraries and individuals to buy. At present, for example the vest pocket dictionary costs $38.50 to buy in braille as opposed to $1.45 in the ink print edition. The cost of production and reproduction has contributed to reluctance of organizations to produce braille and thus to the severely limited selection and range of braille material available.

The Argonne Braille Machine is designed to minimize the difficulty of producing, reproducing, storing, and mailing braille material. This is accomplished by encoding of braille characters on magnetic tape instead of embossing them on paper. An entire book of moderate length can be stored on one three inch reel of quarter inch wide magnetic tape. In operation the tape is "read" by the machine and displayed as regular raised braille characters on an endless plastic belt.

The Braille Machine is approximately the same size and shape as a small portable typewriter. A three inch open reel of tape is mounted on the machine in a manner similar to that used in a tape recorder. The plastic belt passes from right to left across the top of the machine. When the reader places his fingers on the belt, the latter begins to move, and appropriate braille characters appear under the reader's fingertips. The user can stop the movement of the belt and flow of reading material by taking his fingers from the belt. The tape can be rewound and re-read over the whole of its length or just for certain passages. An "indexing" feature permits easy location of material. Any marker, such as a page number previosuly put on the tape, can be located by operating a group of three dials and the fast forward switch.

Braille can be stored on tapes for the machine in several ways; for instance, the material to be read may exist or can be prepared in machine readable forms, such as compositor's tapes or magnetic or punched cards. Such input can then be translated into Grade II Braille by a computer and transferred to tapes, formatted for use on the Braille Machine.

A modified Perkins Brailler can be used in conjunction with the Braille Machine. The braille encoded on the Perkins writer is transferred electronically to the Braille Machine which stores this input on tapes. In other words, blind persons can use the machine for writing as well as for reading. For example, a blind student may take class notes, or a blind professional may write case studies, letters or other material onto the tapes.

Braille tapes prepared by any method can be duplicated to produce any number of desired copies very inexpensively.

Throughout the development of the machine blind persons have tested the equipment, offered suggestions and provided their impressions of the system.

Purpose of the Study

The field study is designed to gain information in several areas, focussing on the kinds of information that will be needed by potential purchasers and users in making decisions about whether braille machines will be a value to them. The study is designed to give information about the following questions:

1. How does reading on the machine, that is, speed and comprehension, of the material read compare with regular braille page reading?
2. What attitudes and feelings do users have toward the equipment? Do they enjoy it? Do they find it easy to operate? How does the fatigue factor of regular braille page reading compare with fatigue experience with reading on the machine? Would blind individuals like to use the machine on a long term basis? Would a person be likely to read on the machine study or recreational material?
3. What characteristics of individuals, such as age or level of reading ability, influence the degree to which they will adapt to the use of the Braille Machine? This question is so broad that the present study can only hint at final answers. The research will, however, provide an opportunity for the first time for a number of individuals ranging widely in some characteristics to use the machines.

Data obtained will provide a base for further exploration of the relationship between individual characteristics and usefulness of the equipment.

4. How does the equipment behave under sustained use? For example how does the machine stand up under the wear and tear given it by active children in a normal school setting?

5. What investment of time is required to learn to read at a certain level of speed and accuracy?

6. What kind of attitudes do teachers and other instuctors have towards the machine after they have had some experience with the equipment?

Method

To investigate these questions, a group of 40 visually handicapped individuals, ranging in age from approximately fifth grade through adulthood, will be trained and tested for their ability to learn to use the Braille Machine. Subjects will practice reading on the machine for 25 hours. Their reading speed and comprehension on the machine will be compared with that of standard braille page reading. Their attitudes towards the equipment and those of their instructors will be recorded. Machinery reliability will be monitored. A more detailed description of procedures used to implement this method is given in a separate section.

Subjects

The number of subjects that can be included in the field study will be depended partly on the amount of time each subject can spend using the machine within a given time period. The demands of work and school as well as the motivation of individual subjects and their teachers will influence the amount of time spent on the project. We expect that subjects each will spend a total of approximately 40 hours on the project. Twenty-five of these hours will be spend with the machines, while the remainder will be used for testing and training for the operation of the equipment, etc. Because of the differential of time available to most students during the summer and winter months, two groups of subjects will spend unequal amounts of elapsed time on the project. One group will use the machines during the summer; the second group will participate on the project during the fall term.

The number of subjects on the project will furthermore be limited by the availability of equipment. Only 30 machines have been produced to date; a number of these must be expected to be in transfer, used for training and demonstration, out of circulation for maintenance, etc., and a number of working machines must be kept in reserve for quick substitution so that subject experience will not be interrupted in case of equipment failures. Given these constraints, approximately 20 working machines are expected to be available to subjects at any given time, hence the number of approximately 40 participants.

The first six weeks of the study will be devoted to staff organization and distribution of equipment. Testing of the first group of twenty subjects will occupy one and a half months. The second group of 20 subjects will use the equipment for about two and a half months. The final two weeks will be used by the staff to complete the field test report and to perform other follow-up procedures.

Some equipment for the visually handicapped is relatively easy to use for school children, but more difficult for adults; other devices are useful to adults, but too complicated for children. To learn more about the applicability of the Braille Machine, subjects with a large age range will be included in the field test, even though the limited sample available in this project can provide only preliminary data. Equal numbers of subjects from the following categories will be used: grades 5-8; grades 9-12; young adults 25 and under, including college and graduate students; and adults under 45.

An attempt will be made to balance the sexes and to choose subjects with at least some range in reading ability in each age group. The range in reading and the balance between the sexes will serve to broaden the base from which the sample is drawn and will provide some preliminary data about the relevance of such factors to adaptability of blind users to the Braille Machine. We will, however, at this time use only one speed range adjustment (approximately 73 to 250 word per minute) for all machines employed in this project, thus requiring that all subjects have the ability to read at least at the lowest speed on the machines. Even though we have found that users - and especially the slower ones - are often able to read faster on the machine than on sheet material, this will limit subjects probably to individuals who read approximately 60 words per minute or faster. While the application of the machine for teaching braille is a fascinating (and promising) subject, it is too large (and too important) to be attempted as part of this project. All subjects will be of at least average intelligence and manual dexterity and will have no handicaps in addition to blindness that will interfere with their learning to use the Braille Machine. A pool of subjects will be assembled beginning with and continuing through the early phases of the test. Teachers and other school personnel can identify suitable children. Notices and publications, recommendations of acquaintances, announcements of meetings, etc. can provide further subjects. Experience so far indicates that interested subjects are easy to locate, although finding a large number of children concentrated in one school system or organization is a problem.

The Cincinnati Public Schools, the Missouri School for the Blind, the New Mexico School for the Blind, the St. Louis County Special School District, and the Western Pennsylvania School for the Blind have all indicated their interest in participating in the field test. Again, experience indicates that other suitable and interested school systems will not be difficult to locate. Criteria for participating school systems will be availability of a relatively large number of students served by one teacher or by relatively few teachers and available time in the school day for the Braille Machine testing program; proximity and ease of access will be weighed also, as will be facilities for locally making minor repairs or adjustments.

Procedure

Two kinds of training situations will be used.

1. Some subjects will use the Braille Machines in school or under the sponsorship of some other organized program.
2. Other subjects will arrange individually with the field testers to engage in the study. This second type of arrangement with the field testing agency is more likely to occur when working with adults and when working with children in the summer. The field testers can use a central location such as an agency for the blind to meet with individual participants.

Where the field testers are working through an organizational structure such as a school, teachers and other school personnel will assume the responsibility for training subjects to use the equipment and for administering all tests except for the intellectual abilities test. These persons can also do the record keeping. In cases where outside organizations are not involved, the field testing agency will contract these services from qualified persons such as graduate students or teachers on summer vacation.

Field testing staff will hold an orientation meeting in each school system or organization in which a testing program is about to be initiated. In this meeting, the staff will explain the purpose of the field test, demonstrate the equipment, describe methods of training, testing, and record keeping, delineate procedures for ordering tapes and for securing machine repair and belt changes, etc. Wherever possible, local persons will be trained to make minor adjustments and repairs to the equipment.

The tests listed in Table 1 will be given to each subject at the beginning of this participation in the project.

Four measures of reading skills will be used. Each subject will read a non-fiction selection geared to his age level. He will be asked to read as quickly as possible without skipping any words. The reading will be timed, and he will afterwards be asked to describe what he has read. ANL staff will prepare key words for each selection by which the tester may identify whether or not the subject has grasped the meaning of the passage. This measure will provide data about braille reading speed.

A set of age appropriate paragraphs from the McCall/Crab series with accompanying comprehension questions will be administered to each subject. This measure will provide data about paragraph reading comprehension.

Four forms of a sentence criterion test are being prepared by ANL staff. This measure is patterned after the sentence section of the criterion test developed by the American Institutes of Research and used in their recent study of the Optacon, a reading aid for the blind. One form of this sentence criterion test will be administered to each subject at the beginning of his participation in the project to provide a measure of reading accuracy and some information of reading speed.

In order to qualify for participation in the project, subjects must demonstrate the ability to read at 70 words per minute on at least on one of the above reading measures.

Each subject will read a selection prepared by ANL staff within modified close procedure. This test will provide a measure of the ability

TABLE 1

PRE-TESTS

Speed test - non-fictional material

McCall/Crab paragraph selection

Sentence test

Selection with modified closed procedure

Verbal scale of WAIS or WISC

Braille contractions test

Initial interview form for subjects

of subjects to use context clues in reading, a skill that is likely to be important in using the Braille Machine where the reading material moves past the user's fingers at a constant rate.

A braille contraction screeningtest will be used to ensure that the subjects are familiar with Grade II Braille.

A test of the intellectual ability will be administered to each subject unless he has taken the test within the last two years. Children 15 and under will take the verbal scale of the WISC; subjects 16 and over will take the verbal scale of the WAIS. These intelligence tests have a long history of use with visually handicapped individuals.

Each subject will fill out the initial interview form for subjects, providing the testers with basic background information and data about reading habits and preferences.

Teachers and other instructors will administer all these measures, except the intellectual ability test, which will be given by a psychologist. The field test staff will administer tests to the first few subjects in order to gain first-hand knowledge of the process.

At the completion of these initial measures subjects will be introduced to the equipment. Subjects will use the Braille Machine teaching manual as a guide. This instruction, as explained in the manual, will be interspersed with periods of straight reading on the machine over the next few days.

It is expected that many subjects will increase their machine reading speed at least up to some plateau level with reading experience. One aim of the field test is to gain more knowledge of the amount of time necessary for subjects to increase their machine reading speed. Experience so far indicates that some individuals will still increase their reading speed after as much as twenty hours of practice while others achieve competence much faster. In order to give ample opportunity for increases in speed to take place during the study, but at the same time not to drastically limit the number of persons who can work with the machines during the time period of the field test, 25 hours will be allotted to practice reading on the machine. As mentioned earlier, this time does not include time spent in learning to operate the equipment or time to set up the machines at the beginning of a practice period.

Instructors will show each subject an edited list of the 50 titles including both fiction and non-fiction available in the tape library and select with the subject one (or possibly more than one) title of interest to him, for reading during the 25 hours.

Table 2 shows the measures and records that will be used for each subject's 25 hour reading period. Subjects or their instructors will keep a log of braille experience, using the weekly record forms, and will fill out the operation of the equipment form. Field testing staff will keep a close contact with the instructors and subjects during the entire period, to ensure that machines are in operation and schedules are being maintained, and to elicit as much anecdotal information about subjects' experiences and instructors' reactions as possible.

After 15 hours of reading practice each subject will take a second form of the sentence criterion test. This measure will monitor subject progress midway through the project.

Table 3 lists post-tests that will be administered to each subject after he has completed 25 hours of reading practice on the machine. All the reading post-tests will be administered both on the machine and in regular braille page form to permit comparison of these two reading methods. Forms of the three reading pre-test will be given as post-tests, that is, the subjects will again read a non-fictional passage to measure speed. A

TABLE 2

DATA COLLECTION DURING SUBJECT'S PARTICIPATION

Weekly record form

Operation of the equipment record

Sentence criterion test (after 15 hours of reading)

TABLE 3

POST-TESTS

Speed test - non-fictional material

McCall/Crab paragraph selections

Sentence test

Final interview form for subjects

Final interview form for instructors

selection of McCall/Crab paragraphs to measure paragraph comprehension and a form of the sentence criterion test to measure accuracy of reading.

For most of the testing materials subjects will be allowed to choose their own reading speed. However, it is interesting to determine whether subjects do choose to read on the machine at speeds that are optimal for them with respect to comprehension and to know how reading speed is related to comprehension on the machine. To gather some information about these issues, reading speeds will be manipulated on the final administration of the McCall/Crab paragraphs. A subject's "typical speed" will be taken to be his most frequently used speed during the last three hours of reading practice. Subjects will read McCall/Crab paragraphs at three different speeds, that is, at their typical speed, at the next lowest speed, and at the next highest speed on the machine. If a subject's typical speed is either the slowest speed or the fastest speed on the machine, the third group of paragraph selections will be read at the next closest speed for which the subject has not already been tested. For example, if a subject typically reads at Speed 6, he will be tested at Speeds 4, 5, and 6. If a subject typically reads at Speed 3, he will be tested at Speeds 2, 3, and 4.

Field test project staff will interview each subject at the conclusion of his experience with the Braille Machine, using the final interview form for subjects. At the conclusion of their participation of the project, instructors will be interviewed using the final interview form for instructors.

Data Analysis

The pre-tests and post-tests may be divided into four classes, as following:

1. Predictor measures, designed to provide information of the extent to which certain variables are associated with a subject's adaptability to the Braille Machine.

2. Pre-tests providing subjects with a baseline of familiarity and experience with specific tests. The goal of these pre-tests is to minimize the bias in post-test comparison between braille page reading and reading on the machine, which may result from the level of familiarity with the measures. This category also includes post-tests to provide such comparisons between braille page reading and machine reading.

3. Information about the characteristics of the sample.

4. Information about attitudes toward the Braille Machine.

Table 4 lists the measures used and the categories of information each will provide.

The Weekly Record Form provides information about the maintenance of schedules, the performance of the equipment, and the relationship between practice time and reading speed.

The Operation of the Equipment form, taken together with some parts of the Final Interview Form for Subjects, provides data about the amount of time spent in training subjects to operate the equipment and the success of this training.

The data analyses will be concerned with

1. description of the characteristics of the sample;
2. comparison between machine and regular page reading as reflected in the reading post-tests and in the attitudes of subjects and instructors;
3. exploration of the relationships of predictor variables (age, intellectual ability, reading skills, etc.) to the final measures of reading, operation of the equipment, and attitudes toward the machine ; and
4. analysis of the training and practice time required by subjects to gain proficiency in the use of the machine.

TABLE 4

CATEGORIES OF INFORMATION PROVIDED BY PRE-TESTS AND POST-TESTS

Measures	Category
Reading tests except the closed procedure	1, 2, 3
Closed procedure	1, 3
Intellectual abilities test	1, 3
Initial and final interview forms	1, 3, 4

HOW TO USE THE BRAILLE MACHINE - P. Biesemeier

Workers at Argonne National Laboratory have developed a method of storing braille on magnetic tape. The Braille Machine changes this stored information back into braille that you can read with your fingers. Books and other reading material can be prepared on tape and read by you on the machine. The Braille Machine also allows you to write braille onto a tape for reading at a later time.

To read, you place your fingers on a moving plastic belt. Braille characters will appear on the belt.

Your teacher or someone from Argonne will show you how to use the machine. You can use this manual to review the instructions as many times as you like and to find out more facts about the machine.

Section 1: Reading on the Machine

Most of the controls and other parts you will use are on the top of the machine. All positions will be described as if you are sitting in front of the machine, ready to use it.

Running along the back of the machine top is the belt. This plastic belt is made with little "bubbles" that pop up to form the braille dots of the material you are reading. If you hold your fingers on top of the moving belt, the braille will come by under your fingertips.

The On-Off Switch: Near the front of the machine top, about two inches from the left edge, is the on-off switch. When the square knob is pushed to the right,the machine is turned on; when the knob is pushed to the left, the machine is off.

The Six Pushbuttons: On the left side of the machine top is a row of six pushbuttons. A pushbutton is in the "on" position when it is pushed down and in the "off" position when it is up. Only one of these buttons should be down at a time. To change from one pushbutton to another, push down crisply the new button you wish to use. Any button you had pushed down earlier will automatically pop up when another button is pressed down. While pushing down one button, do not press down other buttons with other fingers.

The pushbuttons are marked with braille letters. Buttons from back to front, with a short description of their purposes, are as follows:

1. Fast Rewind (marked r): This button and the next work exactly like similar controls on a standard tape or casette recorder. These two buttons move the magnetic tape (not the plastic belt). When the Fast Rewind button is pressed down, the tape will rewind (move upwards its beginning) at a fast rate. The button allows you to find parts of a tape you have already passed by. For example, it permits you to reread part of a book.

2. Fast Forward (marked f): When this button is down, the tape moves forward at a fast rate. You may want to skip parts of a book you are reading, and this button allows you to do such skipping. In combination with the indexing system explained later in this manual, this pushbutton permits you to find a certain part of a book or other material in a short time if the book has been marked in a particular way. Whenever you use the Fast Backward or Fast Forward pushbuttons, you must move a part of the machine called the pinch wheel. Before you try to use these two buttons, read the section in this manual about the pinch wheel.

3. Write (marked w): This is the button to press when you wish to write braille onto the tape. As you read you may wish to take notes about what you are reading. This button allows you to take such notes, storing them on the tape so that you can read them at a later time. Further instructions about writing will be found later in this manual.

4. You will not need to use this button. It is not marked in braille.

5. Read Note (marked n) and 6 Read Book (marked b): Whenever you read on the machine you will use one of these two buttons. Press down the Read Note button when you read material you yourself have written on tape in the machine. Material prepared by your teacher and by some other persons should be read with the Read Note button. Material prepared by Argonne should be read with the Read Book button pressed down. If you are not sure which button to use for reading a particular tape, experiment to see which button is the correct one.

The Reading Speed Control: A speed control makes the belt move faster or slower, so that you can read at different speeds. Near the back left corner of the machine top is the speed control, a knob with a pointed end. This knob can be placed in six positions, one for each of the six possible reading speeds. In position 1, the slowest speed, the knob points toward the right of the machine. Turning the knob clockwise from position 1 to position 6 gradually increases the speed of the belt.

The Channel Switch: Braille material may be stored on two channels of each tape. You may think of channels as being similar to the two tracks on one side of four-track tape recorder. That is, you may read the tape from begining to end on channel 1, rewind the tape, switch to channel 2 and run the tape through again, this time reading the second part of the material recorded there.

To the right of the speed control is a small, square knob. When this knob is pushed to the left, the machine is in channel 1. When the knob is pushed to the right the machine will read channel 2 of the tape. Material will be prepared in such a way that the first part is in channel 1. If the material takes up more space than is available on channel 1, the rest of it will be recorded on channel 2.

The Pinch Wheel: Just to the right of the Fast Rewind pushbutton there is a small cyclinder, the capstan. Next to the capstan is the pinch wheel, a rubber wheel with a metal knob on the top. The pinch wheel holds the tape against the capstan while you are reading on the machine. Whenever you wish to move the tape with the Fast Rewind or Fast Forward buttons, you must first move the pinch wheel away from the capstan so the tape can move freely. Do this by pushing the pinch wheel backward until it snaps into place; then press the Fast Rewind or Fast Forward button. When the tape has moved as far as you wish, press another pushbutton. You may press Write if you are going to write next, or you may press one of the Read buttons if you plan to read. Then push the pinch wheel forward until it snaps into place. Now you are ready to read or write.

When you rewind a tape all the way to its beginning, do not keep the machine in Fast Rewind after you have come to the beginning of the tape. When the tape stops moving, immediately press another button, such as the Read Book button, or turn off the machine. You will be able to hear when the tape stops moving. In the same way, when you use Fast Forward, do not leave the machine in Fast Forward after you reach the end of a tape.

Using the Belt: To read braille, place your fingers lightly on the belt and hold them there. The pressure of your fingers will cause the belt to move. Try not to move your fingers up and down the belt; moving your fingers sideways on the belt is all right. Light rather than heavy pressure is necessary for effective reading.

The machine is made in such a way that less pressure is needed on the left side than on the right side of the belt to cause it to stay in motion. You may want to experiment with placing your fingers on different parts of the belt to see what position you like best.

Small plastic finger rests are available with the machine. With them you can cover part of the belt. You can rest some of your fingers on the finger rests while you are reading the belt with other fingers. Try the finger rests to see if you like them.

You may stop the belt in two ways. If you raise your fingers off the belt or if your touch becomes very light, the belt will stop. You can also stop the belt temporarily by pressing down firmly on it. It will take some practice before you know exactly how much pressure is required to start the belt and keep it moving.

Whenever you begin to use the machine after it has been turned off, there may be mistakes in the first eight braille cells the machine prints.

Sometimes you may take your hands off the belt for a moment but leave the machine turned on. When you put your fingers on the belt again and begin to read, the machine will leave one blank cell before it starts to print more material.

The Power Supply: In order to operate, the machine needs a power supply. The power supply is kept in a separate box.

There are two cords extending from the power supply box. Attach one cord (the one with three prongs at the end) to the electric outlet in the room. The end of the other cord should be attached to the Braille Machine.

Near the front of the left side of the Braille Machine are two rectangular depressions. The plug at the end of the power supply cord fits into the depression farthest from you. The power supply plug will only fit into the hole right side up. A screw sticks out of the side of the plug that should be up when the plug is connected to the Braille Machine.

On one side of the power supply box there is a lever that may be switched from side to side. This lever turns the power supply on and off. The word "on" is written closest to the "on" position of the lever.

Summary of Steps for Reading with the Machine:

1. Choose the book you wish to read. Load the tape onto the machine or have your teacher load the tape.
2. Plug in the power supply to an electric outlet.
3. Plug the power supply into the Braille Machine.
4. Turn on the power supply.
5. Choose the desired reading speed and channel.
6. Turn on the machine.
7. Push down the Read button, marked b.
8. Place your hands on the belt and start reading.

Section 2: Writing on the Machine

As you read, you may wish to take notes on the material, to write in answers to exercise questions in the book, etc. As mentioned before, it is possible to write on the Braille Machine. The material you write will be stored on the tape without interfering with the book recorded for you by someone else. It is as if your notes were recorded on one track of the tape while the book is recorded on another track. Although you cannot erase or write over the prepared book, you can erase or write over your own notes.

Before you take notes on a tape, be sure this tape has been prepared for note taking. Some tapes have spaces for notes, while other tapes do not. Your teacher can give you this information.

You will use a Perkins Brailler, specially adapted, to write on the tape. The Brailler has an electric cord with a plug on the end. Plug the end of the cord into the oblong hole nearest you on the left side of the Braille Machine. Again a screw indicates the side of the plug that should be up when it is attached to the machine.

Whenever you use the Perkins Brailler, put paper into the Braille writer, just as you do ordinarily. This paper will protect the keys of the brailler from damage. It will also provide you with a paper copy of what you have written on the tape.

When you are ready to write a note, push down the Write pushbutton, marked w. Always space seven times before you begin to write a note. Then you can write whatever you like. Use the keys for the six dots and the space bar just as you do in ordinary writing. Changing lines with the Braille writer will in no way affect what you write on the tape. There is no way of backspacing on the tape. If you make a mistake, it is not possible to backspace and correct the error. If you do use the backspacer on the Brailler, it will have no effect on the tape. That is, whatever you write after you backspace will go into the next cell on the tape instead of the same cell.

When you are finished writing, always space seven times. If you do not do this, a few cells at the end of the note may not get written on the tape.

After you have finished writing a note, you may wish to continue reading in the book where you left off. To get back to your place it is necessary to rewind the tape a bit. After you have rewound the tape, put the machine into the read book position by pressing down the button marked b and continue reading.

Whenever you wish to read your own notes, you may do so by pressing down the Read Note button, marked n. In this position you may read your notes, but you will not find any of the pre-recorded book.

Section 3: Indexing

It is possible to mark tapes in such a way that the machine can easily and quickly locate a certain part of the material. This marking is called indexing. Some of the materials you use on the machine may be indexed in this way. For example, the pages of a book may be marked so you can find a certain page in a short time.

On the right side of the machine near the back are three levers. Each lever may be placed in ten different positions, standing for the numbers 0, 1, 2, 3, 4, 5, 6, 7, 8, and 9. Positions are changed by moving the levers up and down. If a lever is pushed up as many times as possible, it is in the zero position. Pushing that lever down once will put it into the one position. Pushing it down again places it in the two position, etc. When a lever has been pushed down nine times, it will be in the nine position.

Using the three numbers you can "dial" any number from zero to 999. The lever closest to you stands for the hundreds. The middle lever stands for the tens, and the lever farthest from you stands for the ones. For example, if you wish to dial 604, you would place the hundreds lever in the six position. Then you would put the tens lever in the zero position and the ones lever in the four position.

If the tape you are reading has been prepared so that each page can be recognized by the indexing system, you can quickly find any page. First dial the page number with the three levers. If the page number is less than one hundred, set the hundreds lever to zero. If the page number is less than ten, also set the tens lever to zero. For example, to set for page 8, dial zero - zero - eight. Then put the machine into fast forward. The machine will automatically find the correct page and will stop at that point.

If you put the machine into fast forward when all three levers are set to zero, the tape will continue to move until you stop it or until the end of the reel is reached.

Section 4: Loading the Tape

There is a plastic cover over much of the front part of the machine top. You will need to remove this cover before you load the machine with a tape. To remove the cover, just hold on to its sides and lift it off.

Unlike an ordinary tape recorder, the tape for the Braille Machine can only be played on one side. That is, the full reel of tape winds gradually as it plays, onto the empty reel. The tape must then be rewound onto the original reel before it can be played again or removed from the machine. Near the front of the machine top is a round, flat hole into which the full reel of tape will fit.

Near the right back edge of this hole you can feel a rubber band. When the tape reel is in the machine, this rubber band presses against the tape. When the motor moves the rubber band, the rubber band causes the tape to move. The rubber band must be moved out of the way before you load the tape reel into the machine. There is a large, flat, round knob near the center of the machine top. This knob controls the position of the rubber band. You can feel a slot going backward and to the right from the knob. The knob can move along this slot. Turn the knob counterclockwise to loosen it, and then move it to the backward end of the slot. Next, turn the knob a little clockwise, to get it in position. This will pull the rubber band away from the tape reel hole.

The pinch wheel must also be in correct position before you put a tape on the machine. Put the pinch wheel into the position you use for fast forward or fast rewind so that the tape can fall freely between the pinch wheel and the capstan.

Now you are ready to place the full reel into the machine. Put the reel into the hole provided for it. Put in the reel so that the tape will move in a counterclockwise direction; that is, the free end of the tape should be pointing toward the left of the machine. The spindle in the middle of the space for the tape in the machine should come up through the hole in the center of the tape reel.

There are several guides and posts through which to thread the tape. The general direction of the threading will be backwards, then to the right, and then forward to the empty reel. There is a low wall along most of the outside of the path taken by the tape as you thread it. This wall can be helpful in finding the place where the tape should go.

Now start threading the free end of the tape. Pull the tape to the left in front of a little post and then backwards between a shorter post (the capstan) and the pinch wheel. Bring the tape backward and to the right around the pinch wheel, following the wall. Pass the tape, now pointing to the right, between a small guidepost and the wall, and then through a long slot. At the end of the slot, bring the tape forward passing it between a guidepost and the wall.

The Braille Machine uses special reels of tape. A pin is glued into the free end of each tape. An empty reel is placed permanently into the machine. Part of this reel can be felt near the right front of the machine top. There is a small hole in the top of the empty reel, just the size to fit the pin on the end of the tape. Find the empty reel, and let the pin on the end of the tape fall into it.

It is important that the tape not be loose when it is played. Now that the tape is completely threaded, wind the full reel a little clockwise if necessary to be sure the tape is not loose. Of course, do not pull the reel so hard that the tape breaks.

Next, set the rubber band in place against the tape. To do this, loosen the knob that controls the rubber band. Then pull the knob forward in its slot as far as it will go and tighten it into position by turning it a little ounterclockwise. As you move the knob forward with one hand, hold the full tape reel in place with the other hand. Holding the reel still will keep the tape from becoming loose as the rubber band moves up against it.

You are now ready to use the tape. If you wish to begin reading or writing immediately, do not forget to push the pinch roller forward.

Section 5: About the Tapes

On the braille tapes one space is left between each sentence and the next one, just as in regular braille books. Five blank spaces are left between paragraphs on the braille tape. A page number is written in brackets whenever a new page begins in the inkprint book, even if it is in the middle of a sentence. A number of page 6 would look like this: [page 6].

Section 6: Taking Care of the Machine

The machine may be harmed if it becomes too hot. To prevent this, do not place the machine where the hot sun will shine on it. Do not put the machine on or near a radiator.

The machine may not work correctly if it is too near another electrical appliance, such as a television set. Your teacher will help you find a place in the room where the machine will not be too close to other electrical appliances.

The tapes for the machine may be erased if they are placed too close to the machine power supply or to any magnet. Do not put the tapes on top of or near the power supply.

When you are using the machine, keep the dust cover on it.

Do not forget to turn off the machine and power supply when you are finished using the machine.

When you are finished using the machine for the day, erase all the bubbles from the belt. To erase the bubbles, push the pinch wheel backward to the position you usually use with Fast Rewind. Press down either Read Book or Read Note. Then place your fingers on the belt to make it move. Let the belt run until you are sure all the dots are erased.

Sometimes the tape keeps moving when the machine is in the Read Book or Read Note position, even though your fingers are not on the belt. This tape motion occurs when there is not braille material on the part of the tape the machine is trying to read. In this case, do not let the tape run any further.

The power supply should be switched on before the Braille Machine is switched on, and the Braille Machine should be switched off before the power supply is switched off.

It is not good to leave the machine in Fast Rewind or Fast Forward after the beginning or end of a tape is reached. As soon as the tape stops moving, press down another button so that the Fast Rewind or Fast Forward button will pop up.

The surface of the machine may be cleaned with a slightly moist sponge and detergent. Be very careful not to let water or soap run into the machine. Dry off the surface completely with a cloth or tissue.

Section 7: When You Have Trouble with the Machine

If the machine is not working correctly, check these points:

1. Sometimes your arm may hit a pushbutton, causing the bottom to spring up. If you are trying to read and no dots show on the belt, check to see that the Read button is pushed down.

2. You may forget to push the pinch wheel back into place after you run the tape in Fast Rewind or Fast Forward. No braille dots will show up on the belt if the pinch wheel is not in place. If you try to write with the pinch wheel in the wrong place, your writing will not be stored on the tape.

3. Check that you have not confused Read Note with Read Book. Make sure the Read Book button is down if you are reading a tape that has been prepared for you. Make sure the Read Note button is down if you are reading material you have written.

DEVELOPMENT OF THE ARGONNE BRAILLE MACHINE SUMMARY STATUS REPORT, December 1972

I. Introduction

In 1966, A. P. Grunwald, a staff member of Argonne National Laboratory, published the findings of extensive experiments conducted to determine reader preference and acceptance of a conceptual system which would markedly increase the literature available to blind people by eliminating the need for cumbersome and costly braille volumes.[1,2] This system, called a Braille Machine, would provide for compact storage of such literature, in coded symbols, on magnetic tape and, on demand, would translate them into patterns of raised dots (called braille characters) on an endless plastic belt. A blind person would then read the information simply by touching the moving belt with his fingertips (see Fig. 1).

The tentative specifications that evolved for such a machine from these experiments were as follows:

(1) The machine should be conveniently portable. This implied that optional battery operation would be desirable, and a weight of approximately 10 lbs.

(2) The machine should be inexpensive. A production cost of less than $500 per unit was set as a goal.

(3) The machine should be durable, with simple and convenient controls, and should require standard supplies.

(4) Presentation of material should be in the B.1 mode, and the characters should be erased after they have been read.

(5) The machine should allow the magnetic tape to move quickly forward and backward, permitting the reader to locate easily any desired page or passage of the text.

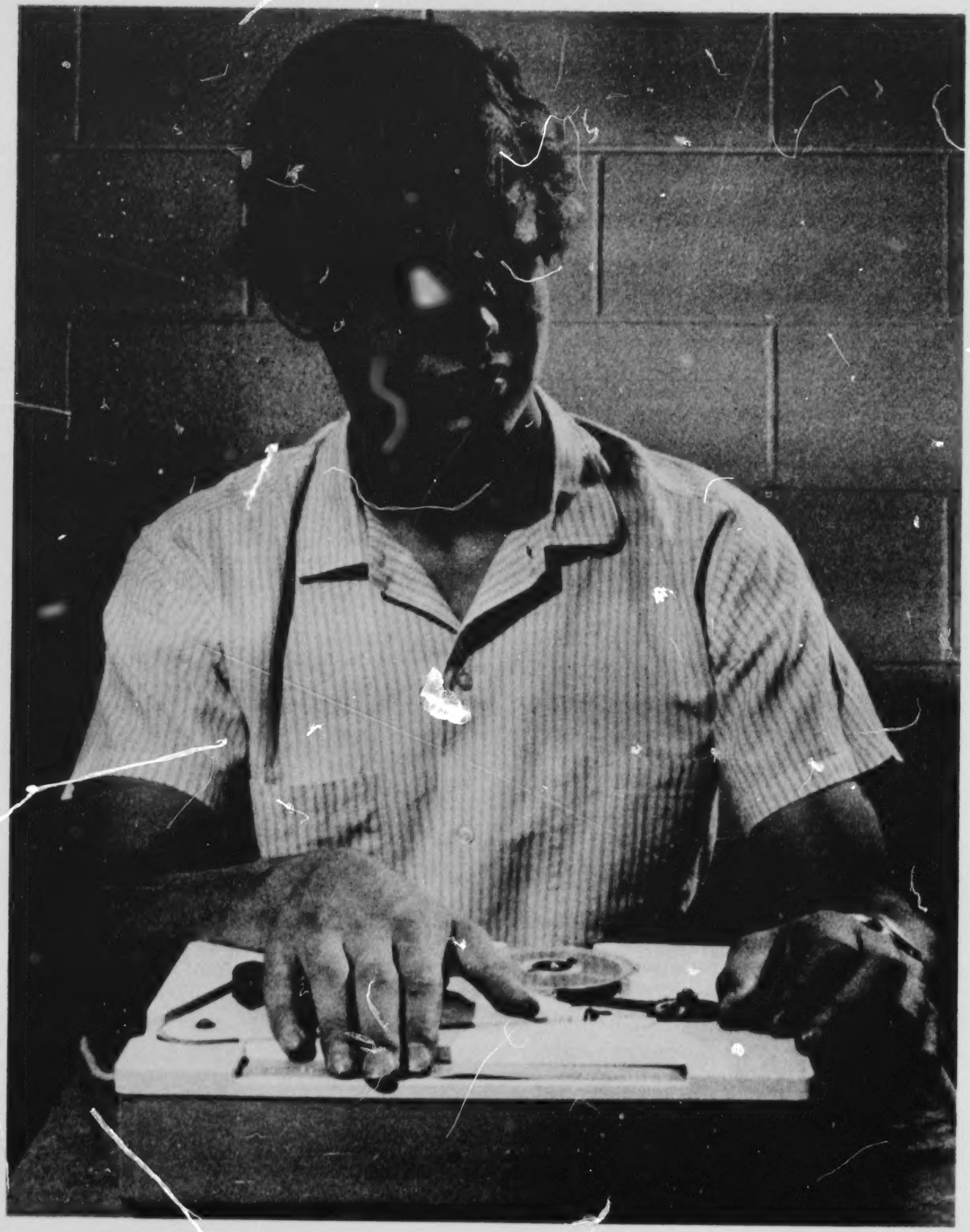


Fig. 1. Peter Grunwald operating prototype Argonne Braille Machine. Mr. Grunwald has been blind since infancy.

(6) The code used on the magnetic tape should be producible as direct computer output and should include pagination, indexing, and cueing features for the reader.

(7) To make the system competitive with ink-print volumes, the tape (including box and reel) should contain at least 1000 words per cubic centimeter of space it occupies.

(8) The maximum rate at which the machine presents characters should be in excess of 22 characters per second.

Subsequently, Mr. Grunwald, utilizing the resources and facilities of Argonne National Laboratory, proceeded to prepare a conceptual design and model of a Braille Machine to these specifications and, ultimately, to demonstrate proof of principle (see Fig. 2).

In 1968, based on the demonstration of the device and in response to a proposal, the Department of Health, Education, and Welfare issued the first of three successive grants to the University of Chicago to develop the proposed system under contract to Argonne National Laboratory. The objectives of these grants can be summarized as follows:

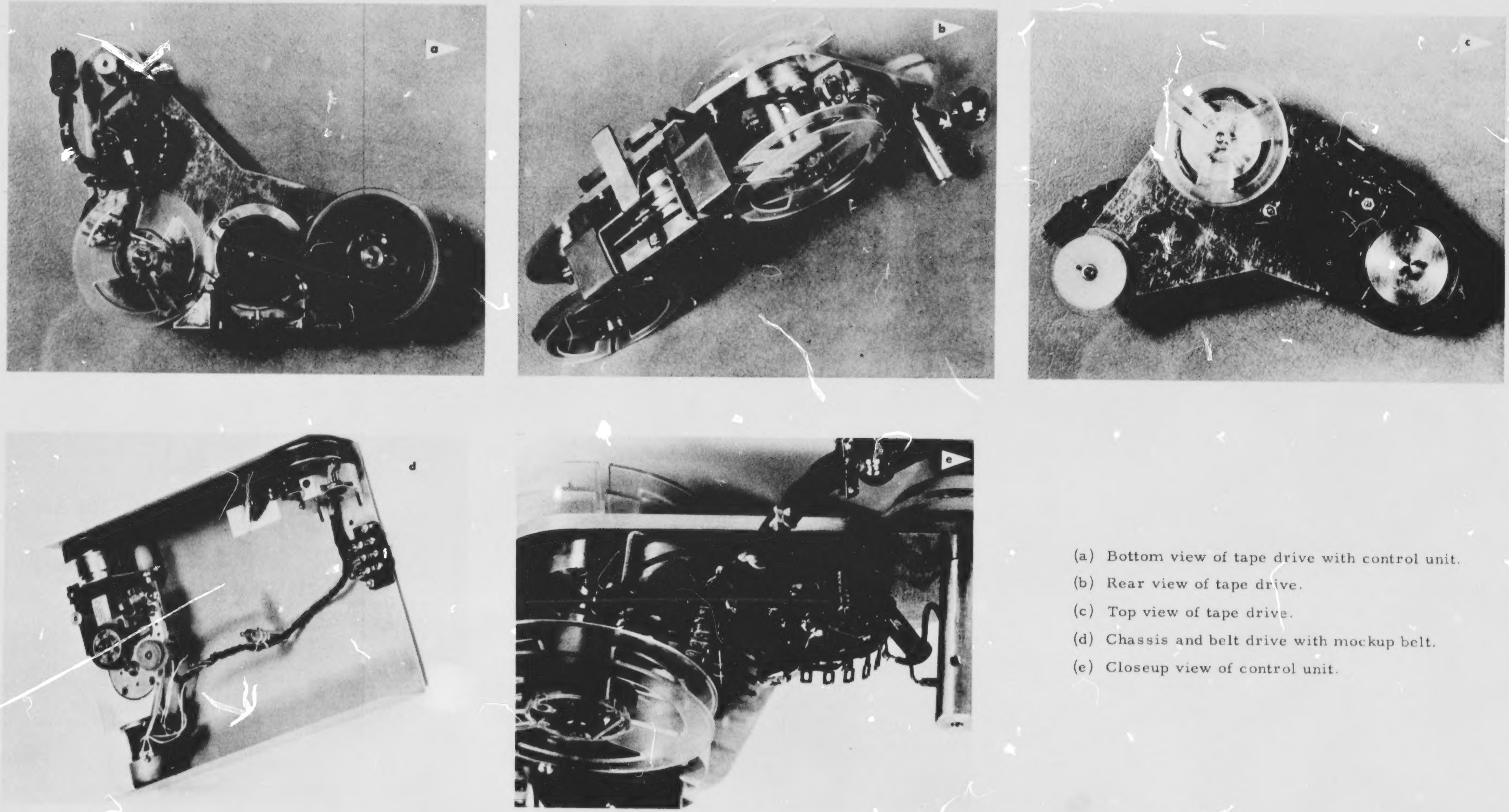
(1) Develop a more definitive design concept of the proposed system.

(2) Construct, test, evaluate, and render an operational prototype Braille Machine.[3,5]

(3) Construct, test, and evaluate a production-type Braille Machine and, if acceptable, provide 30 machines for field tests.

Concurrently:

(4) Develop a PL-1 English to Grade II Braille Translation Computer Program.[4,7]



(a) Bottom view of tape drive with control unit.
(b) Rear view of tape drive.
(c) Top view of tape drive.
(d) Chassis and belt drive with mockup belt.
(e) Closeup view of control unit.

Fig. 2 Subassemblies of Proof-of-Principle Model Used in Support of First Proposal.

(5) Perform an in-depth study of the prospects of utilizing compositor tapes for production of braille reading material.[6]

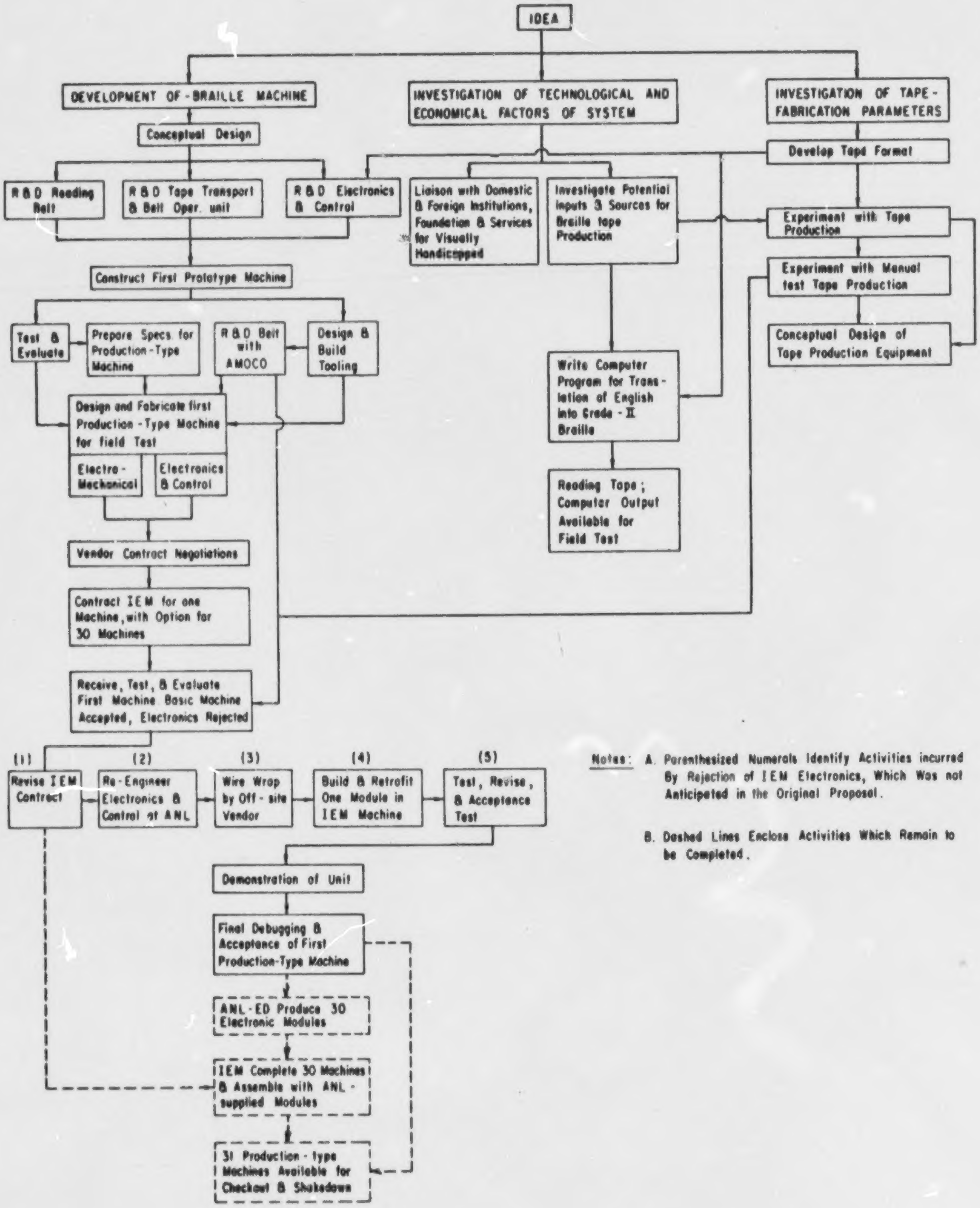
(6) Perform experiments with scanning embossed Braille material relative to producing braille on magnetic tape.

(7) Conduct liaison with cognizant organizations relative to the feasibility and economy of other methods of tape production, in particular, optical character recognition.

(8) Prepare some reading tapes for experimental purposes.

The evolution of the program to develop the Braille Machine is shown schematically in Fig. 3. The principal task in the program has been the development of the machine itself. This has required several iterations of design, fabrication, and testing processes, leading to a production-type model. Important parallel tasks, which are classified as work on necessary support system, included investigation of system technological and economical factors, and tape-fabrication parameters. In Section II, a summary of the program accomplishments is presented, and the current status of incompleted tasks is described.

In order to achieve the goals of the Argonne Braille Machine Program, it has been necessary to develop close and effective cooperation between the Engineering and Technology, Applied Mathematics, and the Electronics Divisions of the Laboratory. Consequently, no attempt has been made to separate the functions and achievements of the respective divisions in this report.


IDEA
DEVELOPMENT OF - BRAILLE MACHINE
INVESTIGATION OF TECHNOLOGICAL AND ECONOMICAL FACTORS OF SYSTEM
INVESTIGATION OF TAPE - FABRICATION PARAMETERS
Conceptual Design
Develop Tape Format
R & D Reading Belt
R & D Tape Transport & Belt Oper. unit
R & D Electronics & Control
Liaison with Domestic & Foreign Institutions, Foundation & Services for Visually Handicapped
Investigate Potential Inputs & Sources for Braille tape Production
Experiment with Tape Production
Experiment with Manual test Tape Production
Conceptual Design of Tape Production Equipment
Construct First Prototype Machine
Test & Evaluate
Prepare Specs for Production - Type Machine
R & D Belt with AMOCO
Design & Build Tooling
Write Computer Program for Translation of English into Grade - II Braille
Design and Fabricate first Production - Type Machine for field Test
Electro - Mechanical
Electronics & Control
Reading Tape; Computer Output Available for Field Test
Vendor Contract Negotiations
Contract IEM for one Machine, with Option for 30 Machines
Receive, Test, & Evaluate First Machine Basic Machine Accepted, Electronics Rejected
(1)
Revise IEM Contract
(2)
Re - Engineer Electronics & Control at ANL
(3)
Wire Wrap by Off - site Vendor
(4)
Build & Retrofit One Module in IEM Machine
(5)
Test, Revise, & Acceptance Test
Demonstration of Unit
Final Debugging & Acceptance of First Production-Type Machine
ANL - ED Produce 30 Electronic Modules
IEM Complete 30 Machines & Assemble with ANL - supplied Modules
31 Production - type Machines Available for Checkout & Shakedown

Notes: A. Parenthesized Numerals Identify Activities incurred By Rejection of IEM Electronics, Which Was not Anticipated in the Original Proposal.

B. Dashed Lines Enclose Activities Which Remain to be Completed.

Fig. 3. Evolution of the Argonne Braille Machine.

II. Program Highlights and Current Status

As discussed in the Introduction, and with reference to Fig. 3, the objectives of the program to develop the Argonne Braille Machine involve three areas of interrelated efforts: (1) development of the machine itself; (2) investigation of associated technological and economical factors; and (3) investigation of tape-fabrication parameters. This section summarizes the highlights, accomplishments, and current status of efforts in each area.

A. Development of Braille Machine

Development of the Braille Machine has proceeded essentially chronologically through the following six phases:

1. Preliminary Experiments

As mentioned in the Introduction, these experiments resulted in a working model of a Braille Reader which demonstrated proof of principle of the invention. It did not include implementation of the electronics, which was expected to be within the state of the art.

2. Conceptual Design of Machine

The Argonne Braille Machine in its present form was conceived of over 3-½ years ago.[3] With the exception of deleting the ability to type manuscripts in the "book mode" and minor changes in tape format, no substantial changes have been made in the basic features, operational modes of the mechanical and electronics, or the data-handling characteristics of the machine.

3. Construction of First Prototype

The conceptual design was then translated into a prototype which included some breadboard electronics and was capable of reading digital patterns from 1/4-in. magnetic tape and temporarily storing the corresponding information (see Figs. 4, 5 and 6). This verified that with unique applications of modern data-processing technology, the electronics portion of the machine would be implemented, although full development would require extensive efforts. Considerable effort was expended on the electronics and tape transport, and, especially, on the braille belt subsystems. In particular, control and drive requirements for the belt-embossing action were difficult to determine and implement, since these requirements were closely related to the belt characteristics, which were at this time not yet fully established. Also, an attempt was made to confine the breadboard in a small volume and in a manner similar to the final unit envisioned. As a result, noise problems were encountered when low-level analog electronics were placed in proximity to the motors and solenoids.

In short, a working breadboard was achieved which approximated most of the specifications. For example, the "search" or index mode operated at tape speeds of 15 in./sec or less; this was not fast enough. Also, operation of the braille belt system was marginal, and some problems with the tape transport still existed. Decision was made to delete the manuscript mode, and it was believed that the remaining problems would be resolved by design modifications as the project proceeded toward development of the production-type prototype machine.

4. Development of Production-type Prototype

During the last 2-½ years, effort has focused on the detailed design and construction of a prototype machine that could be produced commercially in quantities sufficient for future field tests. This effort included continued research and development of the reading belt because of its crucial importance to satisfactory operation and its influence on the

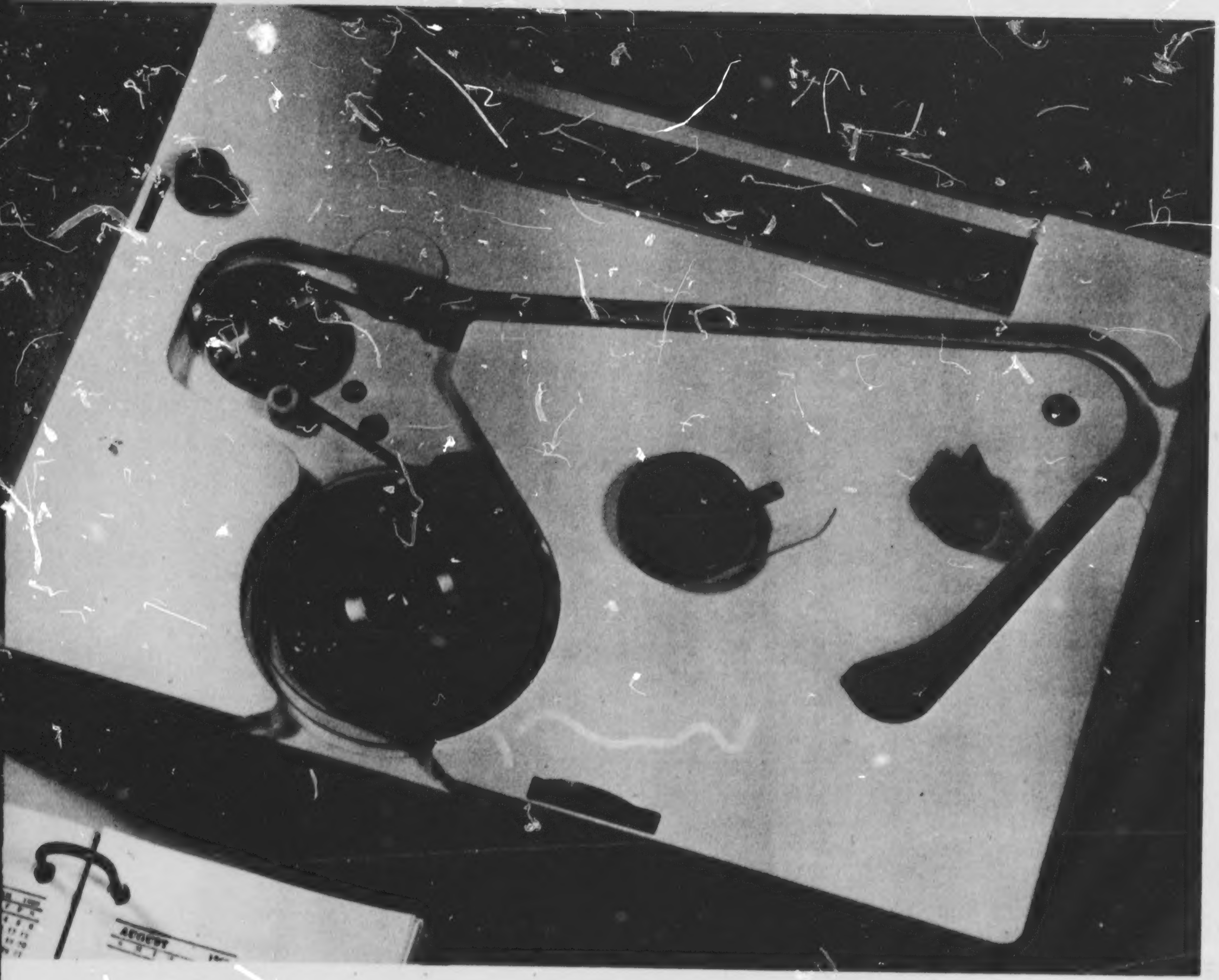


Fig. 4. The prototype Argonne Braille Machine

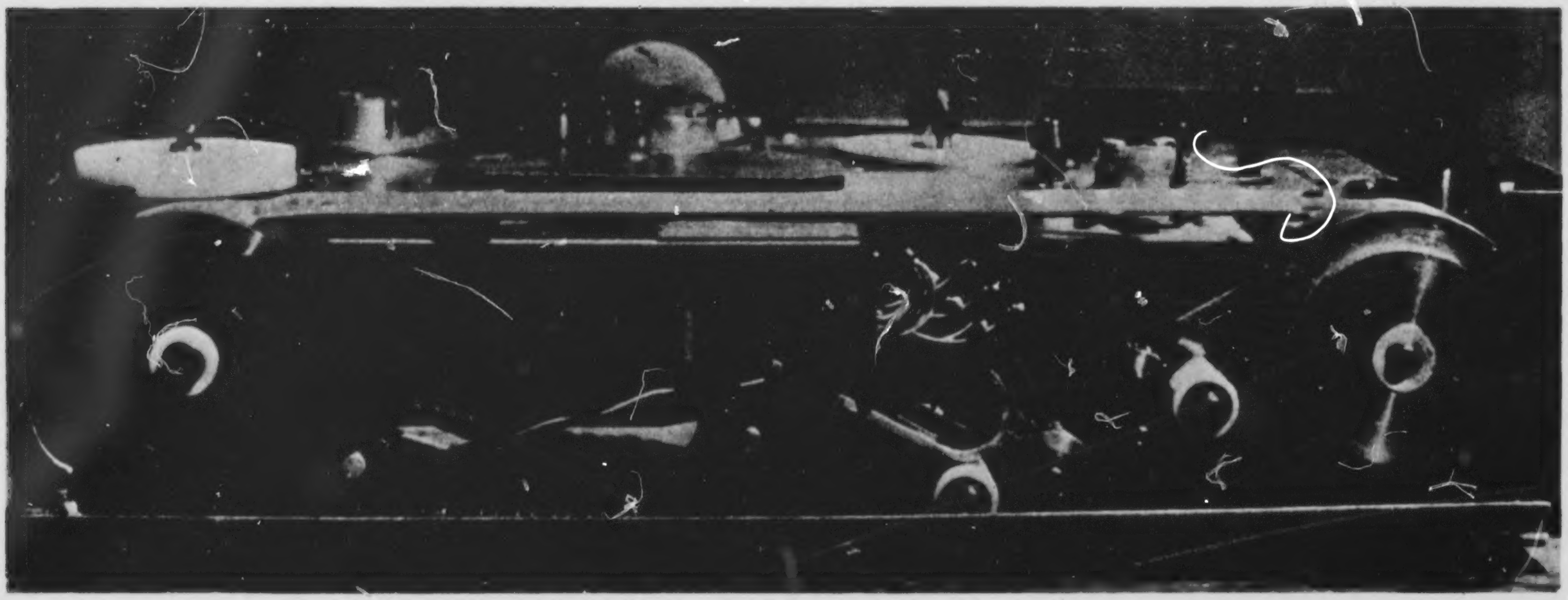


Fig. 5. Prototype Argonne Braille Machine with back cover removed to expose reading belt drive unit

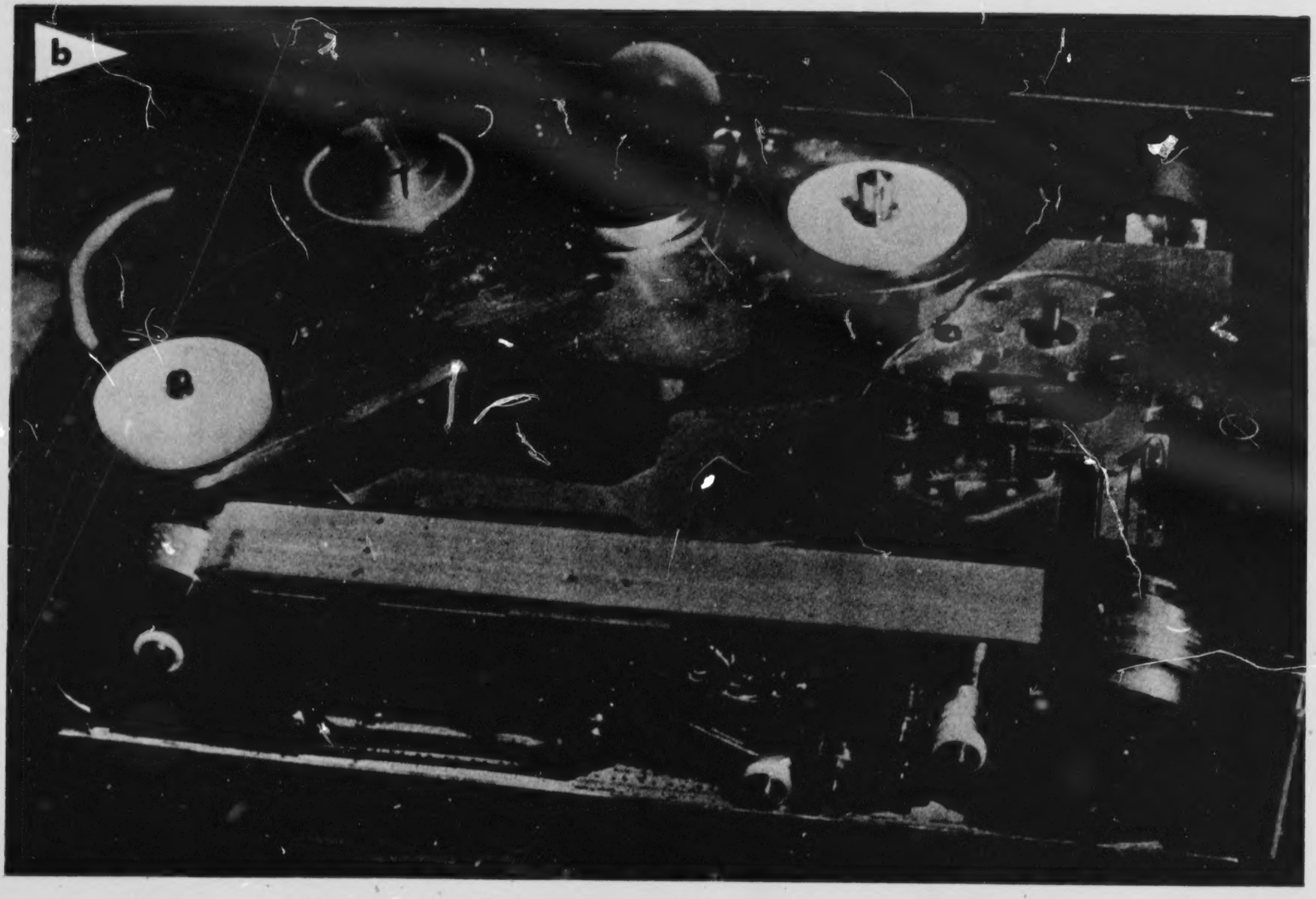


Fig. 6. Plan view of Argonne Braille Machine with top and back covers removed to expose tape drive assembly.

characteristics of other parts of the machine (see Figs. 7 to 11). Detailed procurement specifications were prepared and issued to several potential vendors, with requests for bids on the manufacture of one machine and, if acceptable, an option for 30 additional units.

Several proposals were received and evaluated, leading to the selection of International Electro-Magnetics (IEM) as low bidder. This proved to be a good choice with respect to the mechanical aspects of the machine, but a relatively poor choice with respect to the electronics and data-processing characteristics of the machine. The electronic capability that IEM had exhibited on past systems which were examined no longer existed due to severe reductions in personnel. This was not obvious during evaluation of the proposals; in fact, it did not become apparent until shortly before the first production-type machine was scheduled to be delivered.

5. First Production-type Prototype

The first production-type prototype received from IEM was acceptable mechanically, but not electronically (see Figs. 12 and 13). As a consequence, considerable time and effort was expended in attempting to make the unit work. These intensive efforts were only partially successful; hence, it was decided that IEM could not be allowed to manufacture the electronic assemblies. The contract was renegotiated, establishing IEM as the prime contractor, with the Electronics Division of Argonne as supplier of electronic assemblies to IEM.

Eventually, the first production-type prototype machine was rendered workable. Some problems with the braille belt assembly were largely resolved, and most of the problems with the IEM-produced electronic module were eliminated. Those which remained included minor problems with the tape transport and search mode.

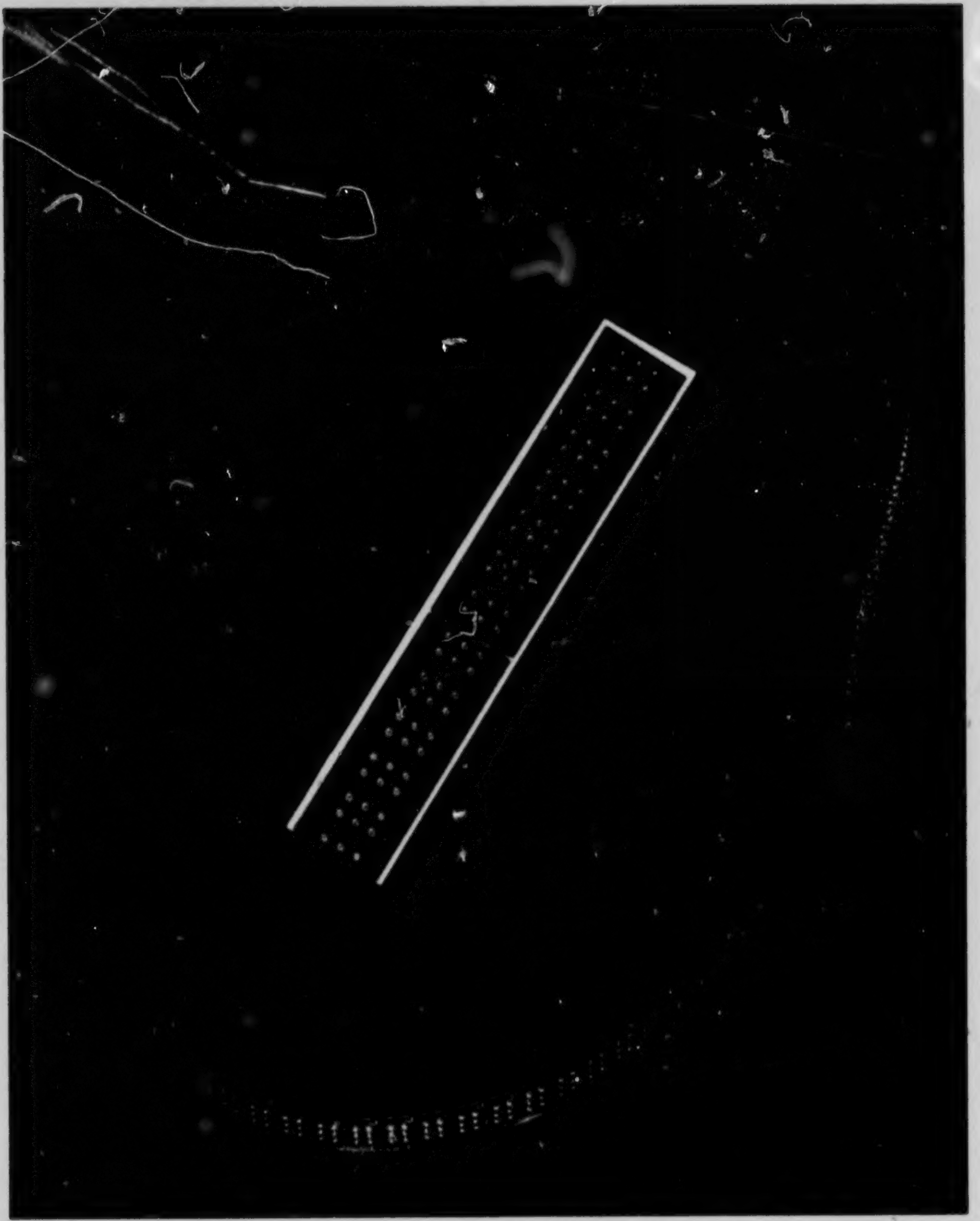


Fig. 7. Endless reading belt. Central image shows actual size of a belt section with final closure weld. The stock thickness of the belt is 0.003 in.

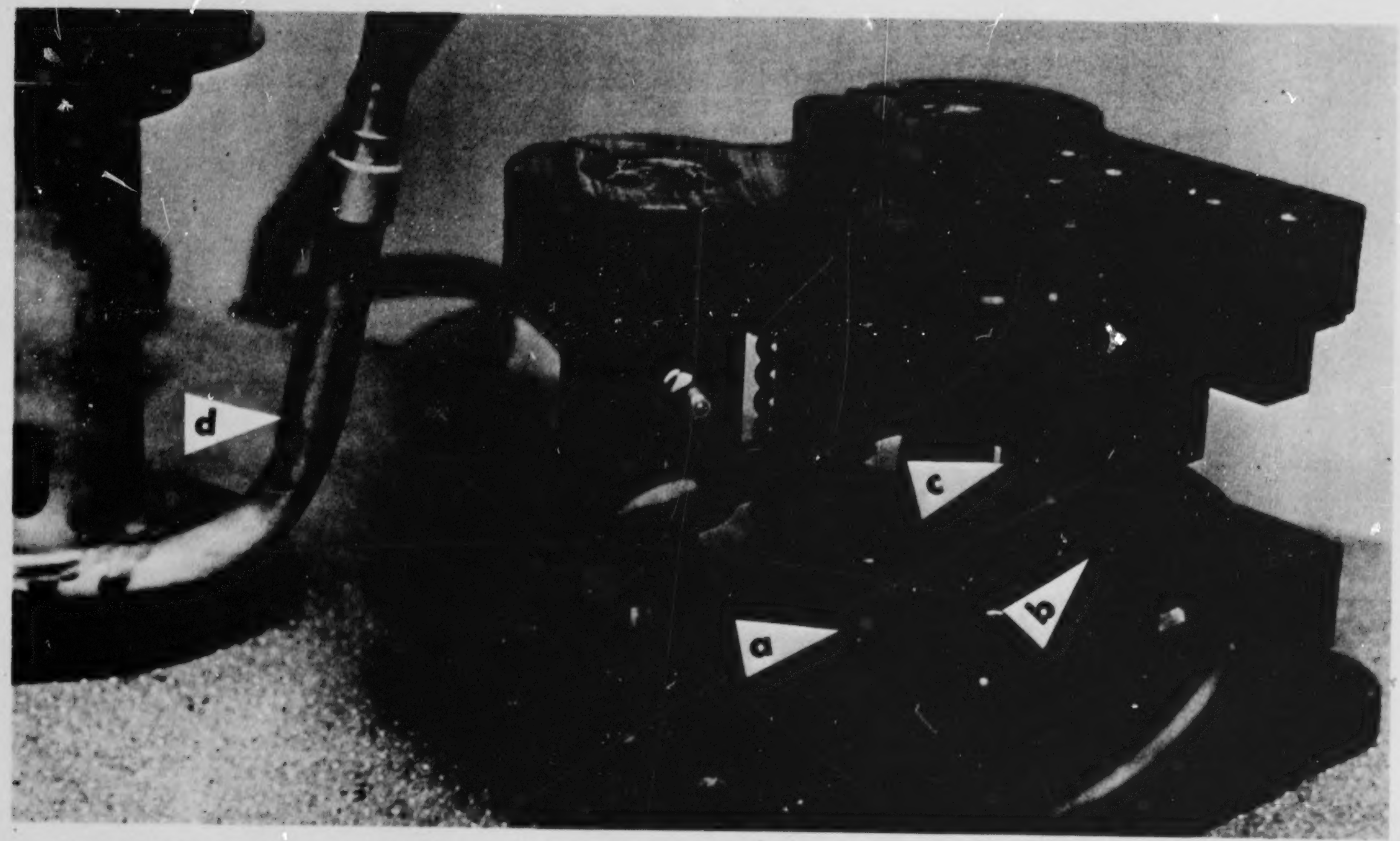


Fig. 8. Belt-forming die, with operating solenoid and timer removed. Belt blank advances incrementally from right to left through channel (a). First station (b) is the perforation die set; second station (c) comprises the bubble-forming die with heated plungers and indexing escapement. The plungers are heated by fluid circulated by pump (d). During each increment, one six-bubble pattern and two sprocket-drive perforations are formed.

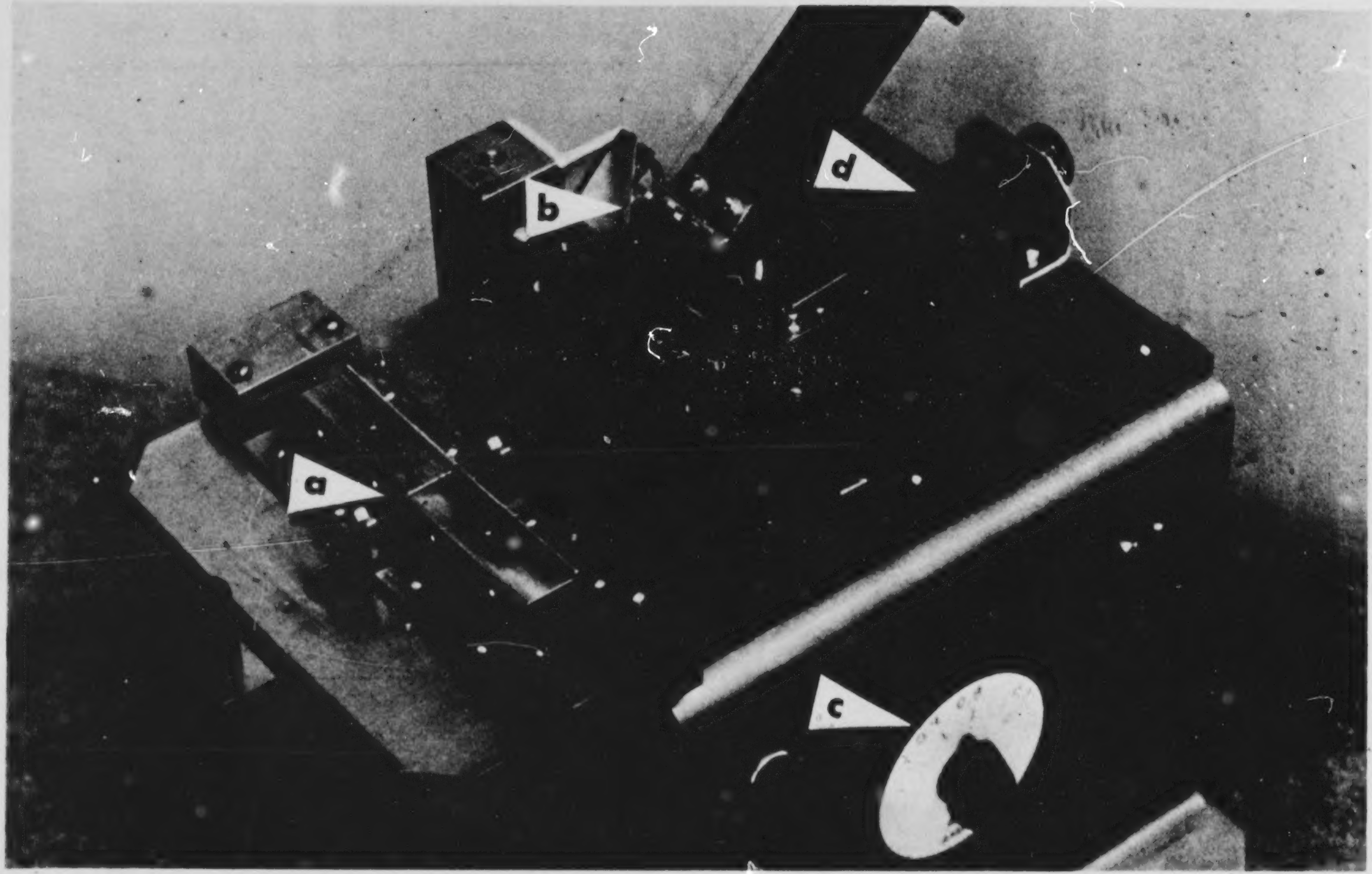


Fig. 9. Electric trimmer and butt welder for closing the belt loop. In operation, the belt clamp (a) automatically separates, the trimmer wire arm (b) swings down and cuts the clamped belt to size. Arm (b) then retracts and clamp (a) moves in over the heater wire to fuse the belt ends. The speed of this motion is controlled by the adjustable dashpot (d); and the temperature of the heater wire is regulated by thermostat (c).

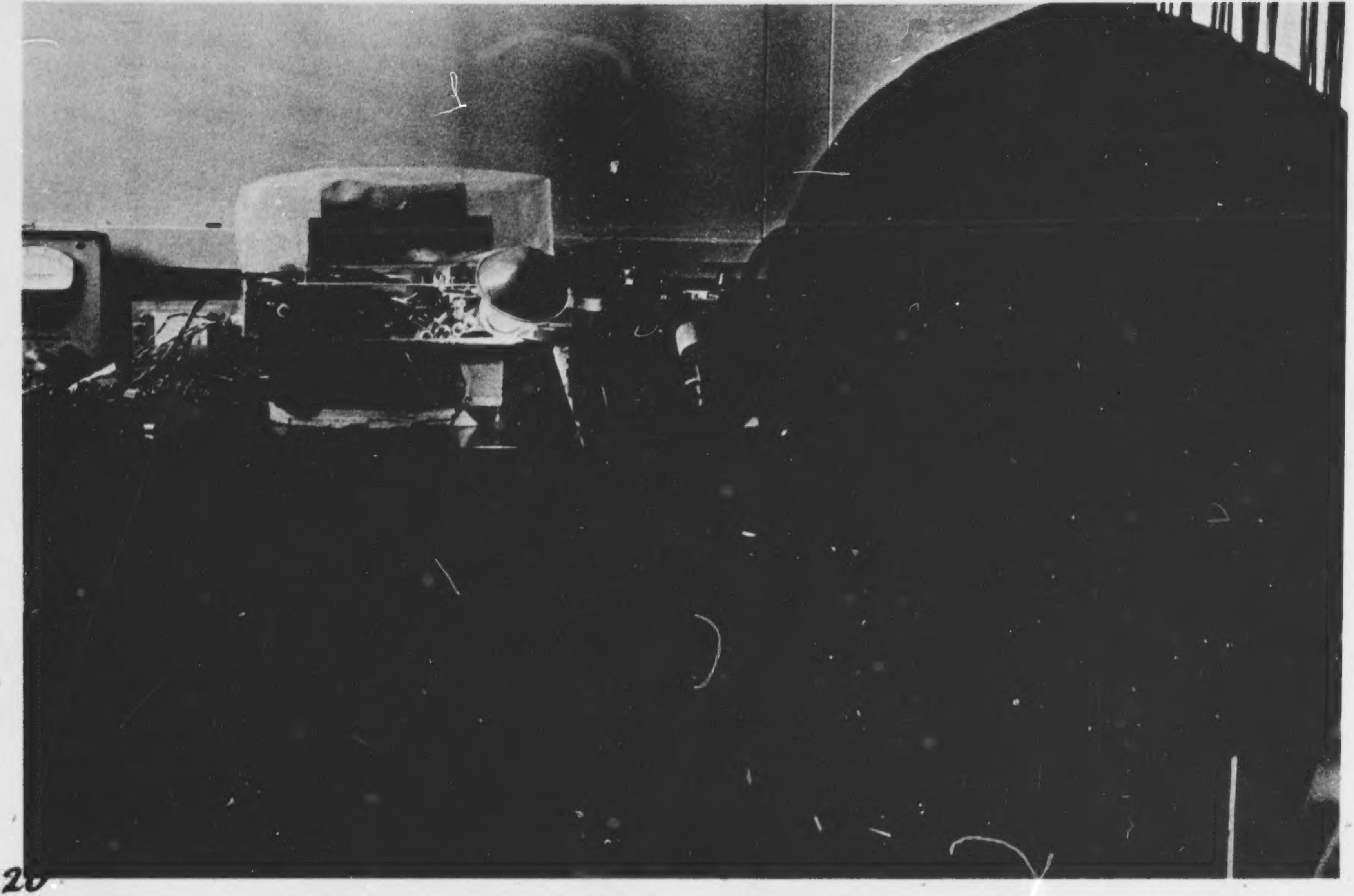


Fig. 10. Technician measuring motion of belt operating style of prototype Braille Machine with strobe light and telescope. The inclined styli and miniature solenoids are visible to the left of the strobe lamp.

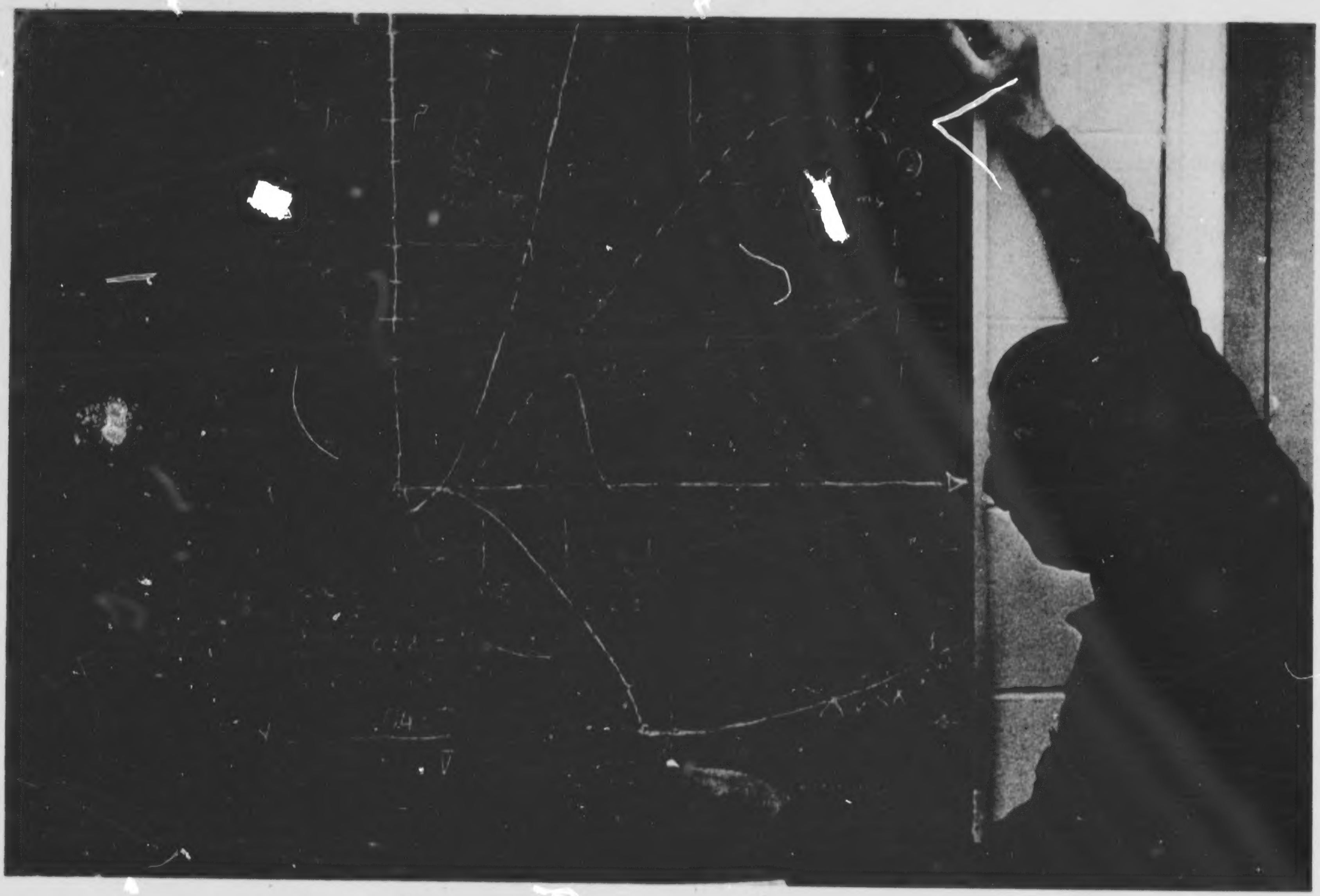


Fig. 11. Analysis of results of experiments to determine specifications for solenoid input electronics (see Fig. 10).

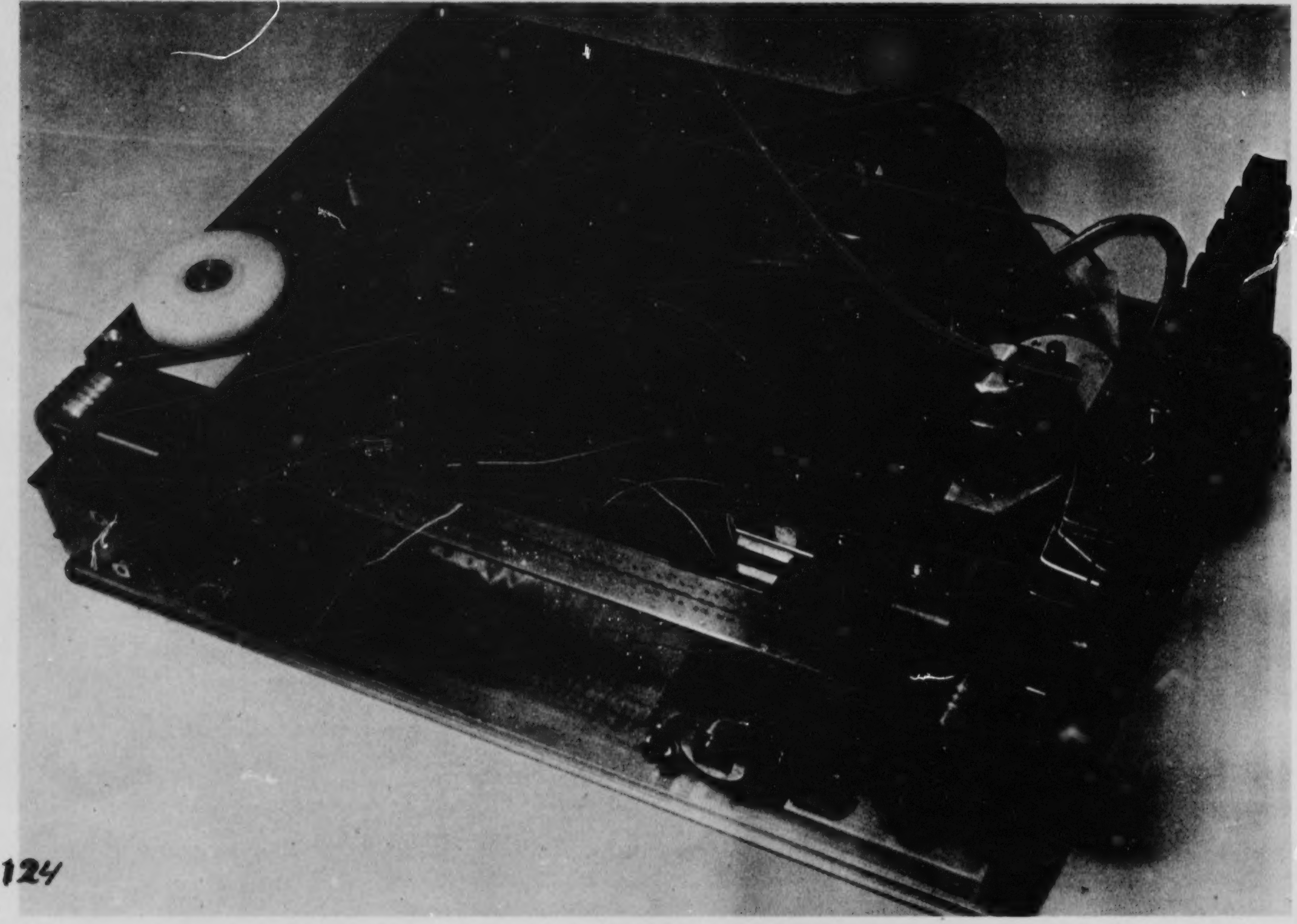


Fig. 12. Electromechanical assembly of first production-type Braille Machine received from International Electromagnetics Co.

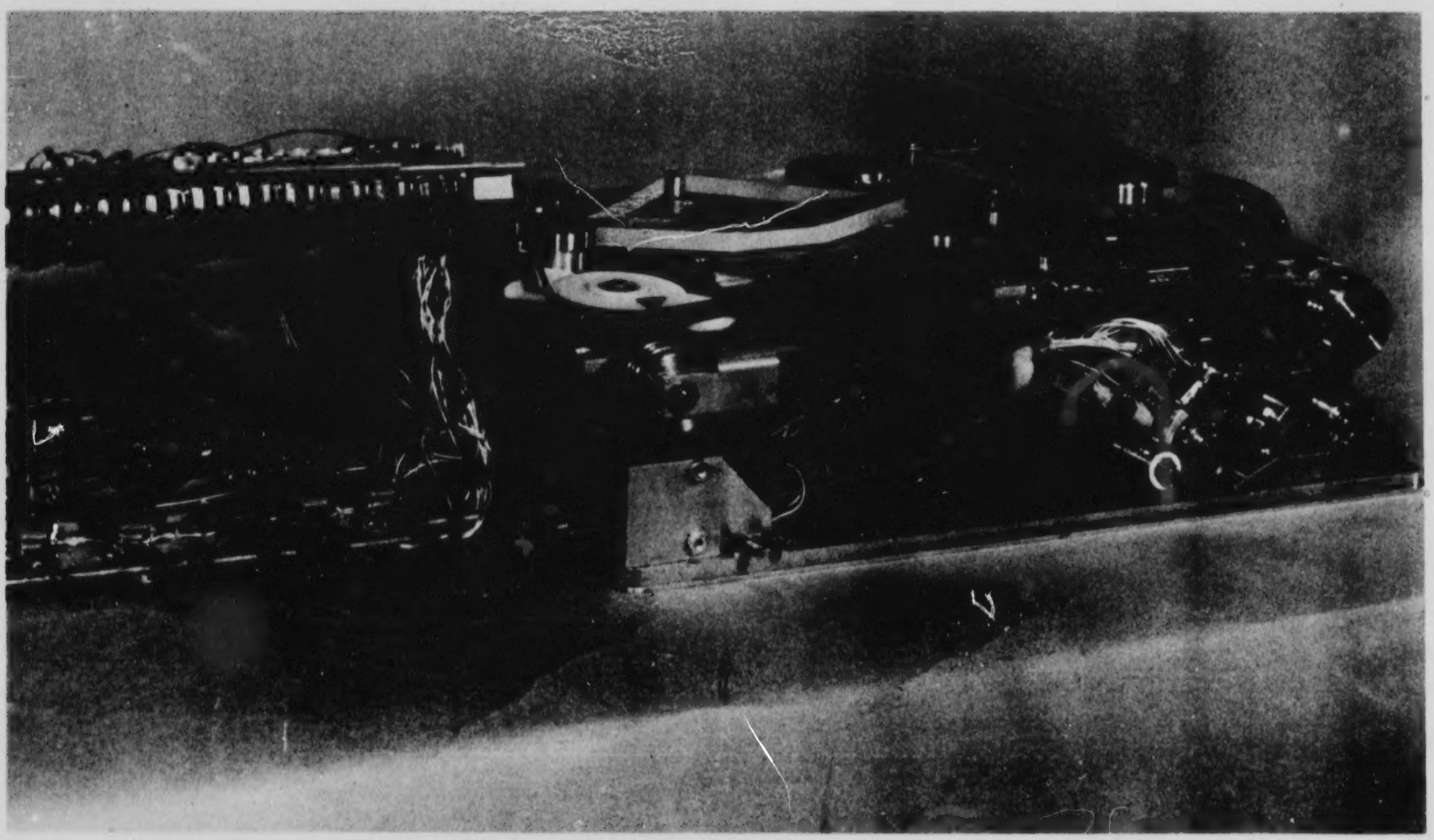


Fig. 13. First production-type Braille Machine, with two-board electronics module (left) removed from chassis (right). The module was adjudged unacceptable.

6. Second Production-type Prototype

This unit consists of the belt and tape transport subsystems from the first prototype which had been debugged by ANL, and electronic assemblies and harnesses re-designed and supplied by the Applied Mathematics and Electronics Division of Argonne. As expected, this first-of-a-kind electronic module revealed additional problems: The analog portions of the electronics exhibited major instabilities which could not be effectively suppressed without degrading machine operation. These instabilities appeared related to component layout and wiring, as subsequently demonstrated. Eventually, the machine was rendered workable but at a reduced performance level (i.e., no search mode and lower magnetic tape information densities.). As a result, the decision was made to revise the layout and rewire the analog part of a second electronic assembly.

The second board was laid out, rewired, and debugged (see Fig. 16). No instability exists, and the second production-type prototype is adjudged to be functional.

In view of the successful operation of the second production-type prototype, fabrication of the remaining 30 machines can now proceed.

B. Investigation of Technological and Economical Factors of the System

Contact and liaison has been established and maintained with, among others, the following organizations: American Printing House for the Blind, American Foundation for the Blind, Library of Congress, National Braille Club, Hadley School for the Blind, Hild Branch of Chicago Public Library, and the Royal National Institute for the Blind.

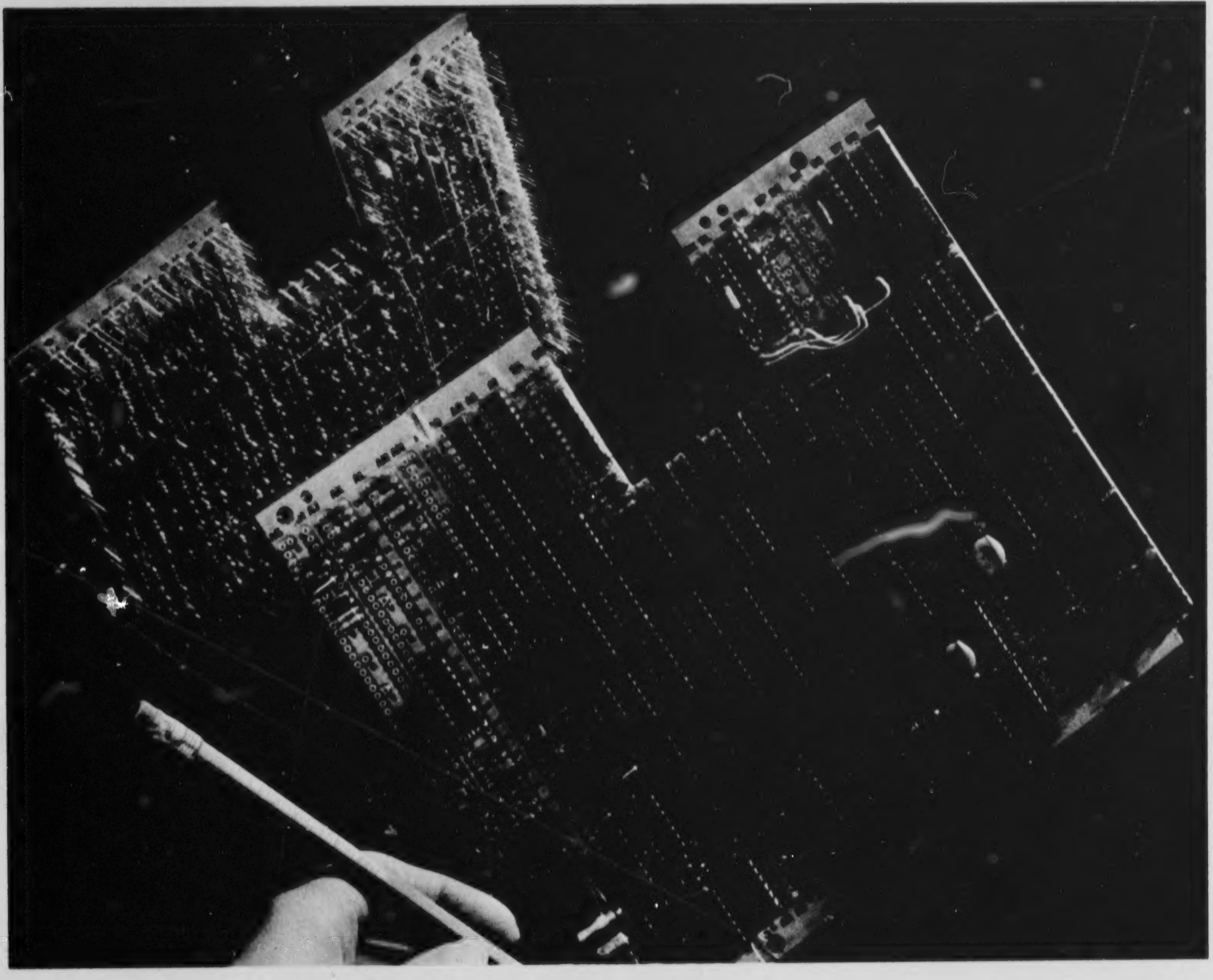


Fig. 14. Single-board electronic module with mirror image of wired underside. This module was designed and built by ANL to replace the module supplied by IEM.

These continual contacts with such a variety of professional individuals and organizations have provided information useful in many aspects of the program, and a stimulus for the generation of ideas. They have provided equally valuable criticism and suggestions. And finally, they have provided the means of keeping interested parties abreast of what was being accomplished in a timely manner, thus amplifying normal channels of communication such as publications in journals, presentation of papers at conferences, and progress reports.

Investigation of potential inputs and sources for braille tapes is, at the same time, particularly difficult and crucially important for the project; no rational hardware design is possible without consideration of input modes. Similarly, hardware design tends to "freeze" future conditions for implementation and deployment, including deployment of software. Thus it was necessary to make strong efforts to acquire the necessary background that reflects the realities of this field. The difficulties encountered were not unanticipated, since corresponding problems have plagued the field for many years. In the present case, the problems were unique due to the nature of the Braille Machine. Efforts to resolve these problems involved searching the literature discussions, interviews, and many meetings involving several ANL divisions and a large number of individuals, spontaneously as well as in more organized form. Much of the data developed in this phase of the project were contributed by an outside consultant.

C. Investigation of Tape-fabrication Parameters

Early in 1969 work was initiated to establish the feasibility of writing computer programs for Grade II Braille translations of ink-print material. These programs were envisioned as being capable of reading computer-compatible compositor tapes being used by the printing industry, translating this information into Grade II Braille, and preparing an output tape which could serve as input to the Argonne Braille Machine. The consensus of the Braille community was that such a system could provide timely, abundant, and inexpensive reading matter for the blind population.

Braille, a language expressed by configurations of raised dots in a 3 x 2 matrix, enables many blind people to read. Several forms of Braille exist. Grade I Braille is a one-to-one character-by-character, translation of ink-print characters. Grade II Braille, the common literary form, is a many-to-one translation of ink-print characters into braille; it reduces considerably the bulk of the resulting translation. To the computer scientist, the task of translation into Grade II Braille is particularly complex because some of the rules of translation are based upon considerations of context and pronunciation.

The efforts in this phase of the program have resulted in:

(1) A Grade II Braille translator program, written in PL/I, capable of translating keypunched input materials and producing a tape containing a form of digitized braille for the Braille Machine. It attains translation speeds of approximately 22,000 characters per minute but does not produce an absolutely error free translation - a characteristic shared by current computer translators of English to Braille II.

(2) Supporting modules including:

(a) Modules for the Teletypesetter (TTS) compositor tape system as well as a proprietary system used by Rocappi, Inc. These modules change the characters on the compositor tapes into a keypunch-like format for input to the Braille Translator.

(b) A dictionary module.

(c) A "retranslation" module which reads the Translator output and prepares "visual" braille for the sighted proofreader.

(3) A program which produces braille on the computer line printer.

(4) A preliminary systems analysis of the entire braille production and distribution system.

(5) Two tapes for the Argonne Braille Machine. One is the text of the book, The Little Prince, and the other the novel, The Poisoned Stream.

(6) A preliminary agreement with the editors of the American Heritage Dictionary to provide the compositor tape from which this dictionary is prepared.

PL/I was chosen as the language for translation because of its list processing and character string-handling capabilities and its conceptual closeness to COBOL - a likely candidate for a module to run on other computers.

A translation program for the Argonne system was written because the existing programs were often written in assembly language for specific computers or for specific groups of users (e.g., computer programmers) or for systems not meeting the input needs unique to the Braille Machine. Specifically, the Argonne Braille Machine required an endless stream of braille (implying no hyphenation) in digitized form in which the presence of a raised dots was signified by a "1" and the absence by a "0". Further, indexing information such as page numbers or word counts needed to be presented in a form discernable to the Braille Machine.

The program system was made modular to facilitate changes or to correct portions of the code as well as to accommodate possible future forms of the input media for the translator and output needs. Thus, for instance, use of an MT/ST tape or a different form of compositor tape as input to the translator requires only a new input module; the translator remains unchanged. The modularity paid off immediately when a slightly different form of the retranslate module enabled a braille computer output to be produced for blind users of the computer. A separate dictionary module, which is read in at execution time, enables one to adapt the dictionary to the vocabulary of the input material, thereby making the dictionary more concise and reducing the execution time for the translation process.

A necessary part of any translation system is the connection between the input and the output language. In the Argonne system, the connector is a dictionary containing words, word fragments, special characters and letters along with their braille equivalent and rules for their use. In operation, a word is read from the input stream, translated by finding it or its fragments in the dictionary, determining if it is appropriate to use the braille characters corresponding to it or its constituent parts, and finally assembling the braille characters into the braille representation of the word.

The retranslate module considers the first six positions of the translator output byte as a binary number and, depending upon its value, branches to the appropriate section of the retranslate code. At this point, the braille corresponding to the character is constructed and printed with its ink-print translation printed below. The output from this module is easily used by a sighted reader to proofread the braille translation.

Generation of actual reading tapes has been initiated. Time Life, Inc. authorized the Donnelley Corp. of Chicago to allow Argonne to use Time Magazine

TTS compositor tapes to prepare a module. These paper tapes were fragmented and contained numerous typographical errors along with typesetting information which was irrelevant to the output that was desired. The errors and extraneous material were difficult or, in some cases, impossible to remove. A blind high school student was obtained to serve as a free braille consultant for the programmers. He learned PL/I and actually prepared the program for the TTS module.

Rocappi Inc. provided a computer-compatible compositor tape containing text for a novel from which proprietary typesetter's material had been removed by preprocessing. The PL/I module was written. Although the tape was relatively free from typos, it still proved impossible to write an input module that would give as correct results as does text which had been manually coded for a keypuncher and then translated. Given this limitation, input modules for these two compositor tape systems now exist.

III. Work Description for the Completion of Argonne Braille Machines

This section describes the workscope, specific tasks, and schedules and delineates the responsibilities for completing 30 Braille Machines.

A. Workscope

The workscope embodies several activities as discussed in the following subsections. The general approach, however, is to first complete final checkout of a prototype and establish a "standard" Braille Machine which meets the following technical requirements: (1) Read book characters at a rate of 5 to 20 characters per second; (2) Read note characters at a rate of 5 to 20 characters per second; (3) Write note characters with manual keyboard; (4) Fast/slow forward and reverse at a rate of 21 inches per second; and (5) Search in the forward slow motion at a rate of 21 inches per second, with the capability of automatically stopping the tape at preselected positions. Subsequently, an additional 30 machines will be fabricated, duplicating the "standard" prototype in all physical aspects (except power supplies), including arrangement of mechanical and electrical components and electrical circuitry. These machines then will be ready for debugging and performance testing, which is included in the next phase of the Braille Program. Thic phase of the program is described in a proposal which has been submitted to and is being evaluated by the U.S. Department of Health, Education, and Welfare.

The scope of work required to complete fabrication of 30 Braille Machines involves the support of six Argonne divisions-- Applied Mathematics, Central Shops, Electronics, Engineering and Technology, Purchasing, and Quality Assurance -- and two commercial vendors -- International Electro-Magnetics Co., and Raytheon Corp. Applied Mathematics Division is responsible for the logic design of the electronics. Electronics Division is responsible for the physical design of the circuitry, procurement of components, and assembly of the modular electronic circuit boards and interconnecting wire harnesses. Engineering and Technology has the overall responsibility and will coordinate the engineering required to complete fabrication and assembly of 30 Braille Machines. Central Shops is involved in shaping the circuit boards. The Purchasing and Quality Assurance Divisions will render services, as appropriate.

Procurement, manufacture, and assembly of the mechanical components and electronic modules (supplied by ANL) will be accomplished under contract with International Electro-Magnetics Co. Raytheon Corp. will wire-wrap the circuit boards, using a computerized wire-wrapping machine whose input is based on wire listing supplied by the Electronics Division.

B. Specific Tasks

1. Final Checkout of Prototype

All functions of the second production-type prototype have been demonstrated to be adequate. This final checkout is to ensure that total performance is in accord with the specification and that nothing has been overlooked in the design, assembly, or the specification. And, since this is a synergetic checkout, performance is measured by the machine itself and, if necessary, corrected to perform in accordance with the technical requirements.

The probability that the final checkout will reveal problems requiring major design changes is considered extremely low; therefore the risk to proceed with manufacture before completion of this task is not great.

Minor inadequacies or improvements which may be identified can be accommodated by a subsequent task assigned to the Electronics Division. Since allowances have been planned for minor corrections, no slippage in schedule or increase in funding is anticipated.

Manpower Requirements: Technician - 3 man-weeks; Staff - 1 man-week.

2. Preparation of "As-built" Drawings for Electronic Modules

Drawings and other documents have been updated by "red penciling," overlay patches, and annotations. These changes will be transferred to master documents in a permanent form. The master documents, in turn, will represent the design of an operating machine and will guide the fabrication of subsequent machines.

Manpower Requirements: Draftsman - 1 man-week; Staff - 0.5 man-week.

3. Technical Liaison

Close technical liaison will be maintained between the Applied Mathematics and Electronics Divisions to ensure a mutual understanding of the needs of each division, and to verify that changes have been implemented to the satisfaction of both divisions. This task is essentially one of consultation and "closed loop feedback."

Manpower Requirements: Technician - 1 man-week; Staff - 2 man-weeks.

Electronics Division

1. Mechanical Sizing of Circuit Boards

Electronics Division will specify the requirements, and Central Shops will produce 30 printed circuit baords properly shaped and sized in accordance with these requirements.

Manpower Requirements: Technician - 0.5 man-week; Staff - 0.1 man-week.

2. Update Wire List

The wire list will be modified, and related documents will be prepared to effect these modifications in the wire-wrapping process.

The electronic modules consist of boards which contain a large number of sockets and pin terminals (between 1000 and 2000) into which many electronic components are mounted. Electrical interconnections among the various pins and sockets are executed by a computer-controlled wire-wrapping machine. The modified wire list and related documents are used to provide the input to the computer controlled machine. The modifications are those which already have been identified in the initial checkout phases of the prototype.*

Any changes suggested during the final checkout will be made manually as part of a subsequent task.

Manpower Requirements: Staff - 1 man-week

3. Procure Wire-Wrapped Boards

The services of Raytheon Corp. will be procured to wire-wrap the modular electronic circuit boards. Raytheon has computerized wire-wrapping machines which minimize wire error and produce good electrical connections. The Laboratory has used its services in the past, with satisfaction. Moreover, preliminary discussions indicate delivery is consistent with the existing schedule.

Manpower Requirements: Staff - 0.4 man-weeks.

4. Assemble Wire Harnesses

Thirty wire harnesses will be assembled. These harnesses are groups of wires which interconnect the various modular electronic circuit boards and permit rapid and accurate connect and disconnect. Layout and

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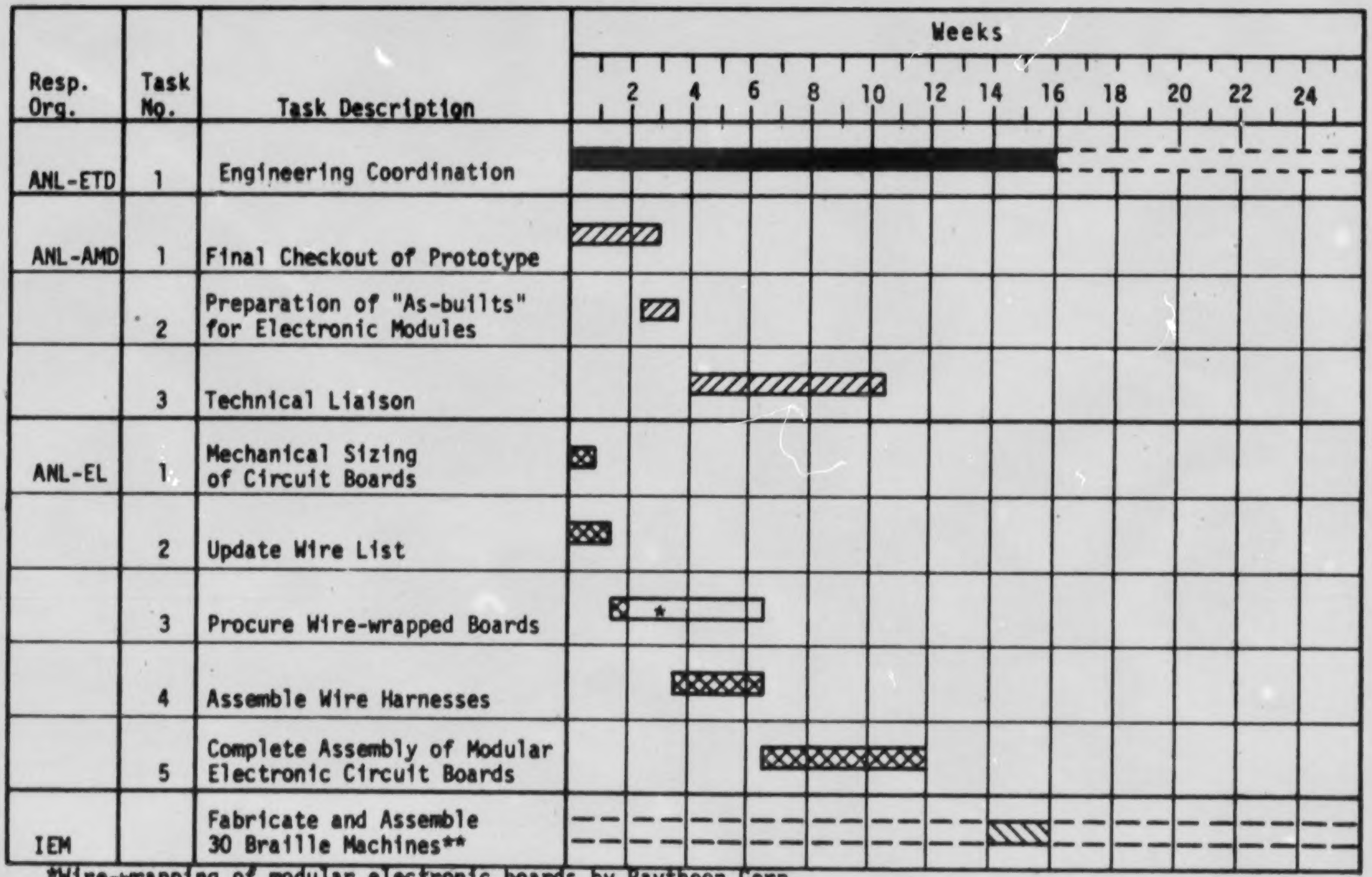
*The modified wire list resulted from the circuit changes found necessary or beneficial during the "Testing, Extensive Revision, Acceptance Testing" phase identified in Fig. 15.



Resp. Org.	Task No.	Task Description
ANL-ETD	1	Engineering Coordination
ANL-AMD	1	Final Checkout of Prototype
	2	Preparation of "As-builts" for Electronic Modules
	3	Technical Liaison
ANL-EL	1	Mechanical Sizing of Circuit Boards
	2	Update Wire List
	3	Procure Wire-wrapped Boards
	4	Assemble Wire Harnesses
	5	Complete Assembly of Modular Electronic Circuit Boards
IEM		Fabricate and Assemble 30 Braille Machines**

*Wire-wrapping of modular electronic boards by Raytheon Corp.
**See text.

Figure 15. Schedule of Tasks to Complete 30 Braille Machines.

wire-grouping has been established; assembly of the harnesses is considered a routine operation.

Manpower Requirements: Technician - 4 man-weeks; Staff 0.2 man-weeks.

5. Complete Assembly of Modular Electronic Circuit Boards

Upon receipt of the wire-wrapped modular electronic circuit boards from Raytheon Corp., they will be visually inspected for loose connections, broken terminals, sockets, or other defects. Subsequently, components (e.g., integrated circuits, capacitors, relays, and resistors) will be mounted in appropriate locations and electrically connected to the proper terminals.

Minor modifications which result from the final checkout of the prototype also will be made within this task. As mentioned previously, these modifications are expected to be few.

Manpower Requirements: Technician - 5 man-weeks; Staff - 0.5 man-weeks.

Engineering and Technology

1. Engineering Coordination

This task involves integration and coordination of the activities of all divisions at Argonne and those of the commercial vendors; preparation of documents, such as progress reports and specification changes; budget control; overall liaison; technical direction of the mechanical aspects of the machine; and overall responsibility for completion of the Braille Machines.

Manpower Requirements: Staff - 6.5 man-weeks; Secretary - 1 man-week.

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CASE HISTORY OF A BIO-ENGINEERING PROJECT, THE ARGONNE BRAILLE MACHINE

A. Grunwald, RESA Lecture, March 9, 1972

Let me begin by saying that I do not like the word "bio-engineering" in the title of this presentation; I used it because it is, as far as I can see, the one most frequently used to express what I have in mind—but it still sounds to me as if it was made up without concern for words' ability to elucidate a concept. In short, I apologize for using jargon, pleading that we are dealing here with an emerging discipline, which has not been around, as such, long enough to develop a mature terminology, that is, one which has meaning clear to everyone.

What we are talking about is a profession concerned with improvement and repair of functions and structures of human organs by design and application of technology and apparatus. One may argue that such activities are not limited to any one profession; indeed much that fits the description is done, for instance, by surgeons, opticians, dentists, or, for that matter, plumbers. The new circumstance lies in the conception of a distinct profession concerned only with the matter under consideration.

I would like to dwell on this subject a little longer. Especially the young seem to be very much interested in this profession; people apparently think of it as serving human needs at once in a satisfactory and effective way, to consider it to be a good thing. I do believe in this idea myself, but it is well to keep in mind that there are few—if any—easy solutions to problems in this field. The difficulties peculiar to bio-engineering, as I see them, stem from two facts, namely that, first, human beings are enormously complex objects and that, second, any interference puts a burden on an organism. It follows from these premises that solutions to bio-engineering problems require systematic, broadly based approaches and, at the same time, elegant methods. Bio-engineers must, therefore, cooperate freely with other professionals and non-professionals in many fields and learn from them all the time; they must especially be mindful of those to be served, not postulate what will serve, but rather find out together with these clients. Putting the situation into a nutshell: rarely is the bio-engineer strictly competent by himself, yet he ought to be strictly responsible for his deeds. I guess there is no general answer to this dilemma; one has to make one's peace with it for any one situation.

So much about a canon of the discipline; now to the case history: I got exposed to the problems of blindness by the accident of having a blind son. In this way, I learned a few things right from the start, for instance, that blind people can do many things which we do not expect them to do, or that their emotional reactions are pretty normal; they do, as an example, not like to be bossed any more than other people. In short, theirs is a rather specific handicap: they simply cannot see.

Now, it is astonishing to observe that even though we are using vision so extensively, there are relatively few things one cannot do at all without seeing; if one puts one's mind to it, most activities can be performed without sight in one way or another tolerably well and many very well indeed. Of the activities common in our culture, I can offhand think only of two from which blind people are absolutely excluded, namely, driving automobiles and reading inkprint. I shall not go here into the many ways and sometimes ingenious devices by which blind people travel independently, keep house for themselves, make a living and enjoy life. I do, of course, not suggest that there are no occasions where it would appear very attractive to one who cannot see to be able to do so; what I do want to impress on you is that blindness is normally not an ultimate catastrophy (and certainly not a stigma) and that its consequences can be very effectively modified. As one of my blind friends put it, blindness should be considered to be a "goddamn nuisance."*

After having disposed of much of my subject so quickly in this easy way (putting things into perspective, as it is called), let me come down hard on what I have left once the inability to drive has been relegated to being a mere "nuisance." I said that blind people cannot read inkprint. That does, of course, not mean that they cannot read at all; as a matter of fact, there are several methods by which the blind do read. There is, for instance, a method called Moon Print which uses enlarged shapes of ordinary letters, embossed on heavy paper, such that their contours can be felt. It is, with some practice, quite possible to recognize such letters by touch and to read (or perhaps better, to decipher) words or sentences. This system has, however, practically disappeared because it is very cumbersome in several ways. There is a very modern implementation of this general approach, namely the Optacon of Linville and his collaborators.

Here a scanner or probe is moved by the user along lines of an ordinary inkprint book or other text, and with ingenious and skillful utilization of solid state circuitry and piezoelectric transducers, a reader's finger is subjected to an impression in real time similar to the one he would receive if his finger would sweep over a relief of the same letters that the probe sees.

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*I realize, of course, that such terms are highly qualitative and thus relative, and I would be the first to warn against making inappropriate use of them; for instance, with our present dating habits, for a young male not to be able to drive may be a very serious nuisance indeed.

What Linville does is an example of "good" bio-engineering, namely, to let the human client do what humans are exceptionally good at, that is to recognize gestalt (something for which machines are absolutely blind), and similarly assign to the machine the function to which it is particularly suited, namely, to condition the available signal in a way which makes that signal suitable for the human's processors. The Optacon is, however, a relatively slow reading device when it is used with normal script, which is so terribly redundant that it "overloads" the available tactile channels. (This redundancy is tolerable and script is more suited to visual receptors.) The slowness is thus inherent in the script more than the machine, representing an "ecological" factor, over which one has little control, a frequent frustration for the bio-engineer.

There are other reading devices for the blind, using spelled speech, encoded speech and other tricks, which I will ignore here, even though they are quite interesting in many ways, in order to be able to devote what space we have left to braille; I chose to do so because braille is at present, and as far as I can guess in the future, the only widely accepted vehicle to make large amounts of reading matter available to the blind. I note in passing that I do not consider acoustical recording "reading matter"; it is a different--valuable--method to prepare information for anyone who can (and wants to) hear; in any event we are all familiar with acoustical recording, and thus I do not need to talk about it here.

Braille then!

The braille code consists of six dot matrices comprising "dots that are there and that aren't there." Each matrix is called a character, and it conveys specific information to the braille reader. However, braille is not just an alphabet, but it is 63 characters (or 64 including 6 zeros), which, incidentally, exhaust the permutations and combinations that can be done with 6 elements.

The use of the 63 symbols (compared to, let's say, 26 in writing English) results from three characteristics of the braille system; it is used not only for spelling words but also for numerical and all other mathematical information, and also for writing music, and finally as a shorthand system. In other words, there are many words, syllables and letter combinations, which are conventionally abbreviated. The code for the commonly used system of abbreviations goes by the name of Grade II Braille, and most braille readers are so used to this code that Grade I (which is a letter-by-letter transcript from English) actually makes reading for them awkward and tedious.

The size of the characters is interesting. The standard spacing between dots is 2.5 millimeters, and between characters it is 3.75 millimeters, which appears to one not used to sensitive touch pretty small. This should remind us that it is for a seeing person extremely difficult to understand how braille is used, how it works, what the pros and cons, the pitfalls, and the advantages are. This sounds strange -- what can be difficult about 6 dots embossed on a piece of paper or whatever the material is? Well, it turns out that we tend to visualize, and I use that word deliberately, visualize a pattern of 6 dots and in one glance see whether a dot is here or there in a particular location. But this is not how a blind person explores a braille character. The method that a skilled blind reader uses is to scan a line in one sweep at a rate of up to 22 characters per second. I think it is intuitively obvious that at such rates one is not exploring geometry but something else. Well, it turns out that what is being explored is rhythm. That is one of the things which would hardly occur off-hand to a person who has not had experience with braille and which are, more over, fairly difficult to grasp fully. I mean, if one tries to visualize sweeping a 6 dot pattern under his fingers at a rate of 22 characters per second, just about everybody would "feel" that to distinguish anything at this rate is impossible. Let me dwell on this subject a little longer. The reason that I talk like I know something is that when this whole project started, we felt very strongly that in order to do some intelligent engineering, it was mandatory to understand the braille reading process better than we did. The experiments we did for about a year were accordingly not concerned with engineering a device, but with questions like how fast braille can be read. I'm very glad that we did start out that way because otherwise we would never have guessed the severity of the problem that we are up against: to write braille characters on a moving belt at a rate of 22 characters per second is an engineering problem which is "hairy," to say the least. If we hadn't anticipated this difficulty when we started to look at actual devices, we probably would have had any number of false starts and great disappointments.

Now, how did we actually determine braille reading speed? Well, the task seems very easy: what you do is to let somebody read text and you know how many words the text contains; use a stop watch and divide words read by time elapsed; and that is it. But it isn't that easy because there is, of course, the difficulty that somebody can cheat. By "cheating" I do not mean that the subject intentionally says "I read it" while he actually did not, but where he puts in a little skimming or a little guessing, where he interpolates or extrapolates from the information that he really has and so on, all of which would for an engineering type study distort the information that one wants to have; a second and even more difficult problem arises from the very speed of the process that we wanted to measure. At first people were thinking about rates of perhaps one or two words per second. But if you get to speeds of, say, 5 words per second, counting becomes quite a problem. So, how do we measure the rate at which somebody read with any degree of assurance what he really read? Well, one asks, "Wouldn't it be nice if a reader just pronounced the words as he reads and we knowing the words of the text just check whether he pronounced the right words?" Fine, but in Grade II Braille with an average of about 4.2 characters per word, 22 characters per second turns out to be about 320 words per minute, which is faster than anybody can speak. So that didn't hold up. At this time we postulated that while one is reading braille at a particular rate, his fingers sweep over the line at a steady rate of n centimeters per second, so it would not matter if one placed empty gaps between words in the text. That is, the rate at which characters are presented while a word is read would in this case not be affected. We speculated that while there are characters you have to grasp them at the rate of presentation, but that the little extra time while the gap passed could be used to complete pronouncing a word. I have found considerable opposition to this theory, but I am personally convinced that it is a perfectly good one; I am convinced because we have checked it by two other and independent measurements and the results were in all three ways identical. Checking of the proposed method was done as follows: First, we took meaningless dot patterns and cross checked for resolution. When one presents strings of, let's say, dots that are and dots that aren't there, for instance, let us present a string of dots at a certain rate and then all of a sudden change from one regular pattern to another, can a subject at a given rate identify the change or not? He can signal recognition by saying "yes" or by stamping his foot or what have you. In this way, one can check at what speed a pattern disappears or appears to the subject. It turns out that with some perturbations, which we can go into later, the highest rate at which resolution is still achieved comes out the same as the maximal rate in the reading tests which I described. The other check we did was to use the "conventional" method, that is, we gave some of our subjects a text which contained a certain number of words from a high school biology text; this subject matter was chosen to make it difficult to guess too much and, at the same time, not too difficult to read. We said to the subjects, "Please don't cheat; please read everything; don't guess, be sure that you're sure you've read every word. Now, ready, go," and with the aid of a stop watch we timed how long it took them to cover the text. After some practice and with intelligent, cooperative, and skilled braille readers, we got with this method rate numbers which are very close to the previously measured ones. Now, here is one of the "perturbations" we found: in the "conventional method tests," a rather consistent difference existed; it took ∿ 8% longer than in our "simulated" reading tests to cover the same number of spaces. To evaluate this, bear in mind how we conducted the simulated reading tests: we had a long strip of paper on which braille characters were embossed, and this strip of paper was run between rolls, under the fingertips of the user; we had speed controls so we knew exactly at what rate we were speeding the strip by his fingers; thus, we knew directly the rate at which dots impinge on his fingers. So in this case, there was one long strip of paper, whereas for the conventional test, the braille characters were arranged on a page in lines; so you sweep one line and then you go back to the left margin to start another one. We tried to do some high speed movies on that and we came pretty close to 8% when we estimated from that the time "lost" by the subject in transfer from one line to the next. So, I for one am convinced that this method of presenting a steady stream of random words and empty spaces for testing braille reading speed is accurate. I forgot to mention that we did use single words and not whole sentences, because again you have the problem that a reader can easily complete a sentence without necessarily having read it completely; so we used words which were carefully chosen not to contain any similarity of form and subject. We even tried to stay away from any alliterations so that subjects could not guess the first letter. If the person said "fox" where the word was "fox", we checked it off, and if he said "box", we noted this as a partial score, and if he missed a whole word, we scored 0.

So, this is how we determined maximal reading rates and the top rate of 22 characters per second as an upper boundary for possible resolution. Now I want to say something quickly on the repeatability of these rates.

Strangely enough, we found that this 22 characters per second appears to be not just the highest score in our sample, but something of a magic number Not only does it change little, if at all, from one person to another in the elite group, but it seems not affected by fatigue or by anything that I can think of -- of course, if your fingers are frostbitten; we didn't try that. But I once did a nasty thing to my blind son; I woke him up during the night and before he really had time to recover, said, "Here, read this," and he came out with the same score. I don't think he know what he was doing, but the score was the same. It really is none of my business to speculate about how it is determined in nature; all I need to know is that it appears to be reliable. But, of course, it's tempting to speculate why this is so. And so I did a little bit of reading on neurology. The firing rate of human neurons, at least to my very, very spotty knowledge of the subject, is not exactly known, but for frogs it's about 30 to 32 per second. Now this is not very far from 22, but of course not close enough. But if you look at the dot spacing within one character and between characters, you notice that at 22 characters per second the sweep rate is almost 14 cm per second and the time interval between dot impingements on the fingers is 1/54 and 1/36 of a second, depending whether you look at inter- or intra-character dots. Thus, it would seem that perhaps human neurons fire at up to 30 pulses per second, and that while at 22 characters per second the intra-character space is not resolved anymore, the inter-character space just barely is. This probably means, at least I speculate that it means, that while you cannot resolve two subsequent dots within a character as two separate dots, you have somehow a sort of subscript type of information which tells you whether it's two or one; if "two dots," even if it doesn't feel like two, feels different from a "one dot," then you can actually show that there is enough information to reconstruct a character from this and the resolved inter character dots. This is apparently what happens. It was interesting to me (confirming to some degree what I have said) that most of the good readers quite often do not read at this 22 characters per second but at ∿ 2/3 of that rate; at this speed resolution of all dots would be expected. In other words, it would appear that reading in this fashion may be easier and that those who are not in the top class of braille readers still need to resolve all dots separately; but those who have been long enough at the business, who are motivated enough or brilliant enough, can do without complete resolution.

So, braille is a pretty interesting system, I dare say. Even though it was designed in the early 1800's (by a blind Frenchman, Louis Braille) and people have since then tried often to improve or optimize it, so far there have been no significant results. I mean, people have tried to add dots to increase the number of available characters, played with the size of the characters, etc., yet my impression is that the first thing that Louis Braille did was already close to optimal for its purpose-- a very unusual phenomenon, but it seems to be so.

Well now, what's wrong with this wonderful system? It can be read at 320 words, up to 320 words, so the tedium that most people are worried about, thinking, as they do, of braille as a very slow medium, really doesn't seem necessarily to apply. I think that there may be not too many seeing people who read faster than 320 words per minute very frequently. I wish I did, but I don't. At least if I want to know what I'm reading, I'm probably slightly slower than that. I do, of course, not imply that it would not be equally useful to seeing and blind to be able to read much faster, but I want to dispel the wrong notion that a good braille reader is worse off than the average seeing person; I want to establish by comparison with generally familiar references that braille is not a marginally, but quite acceptably, useful system and that is a system which-- quite contrary to commonly held prejudices --can, for instance, compare in speed very favorably with verbal communication. The first question then ought to be: can everybody read braille "that fast?" The answer is a resounding "no." Most blind people, even those who have learned braille and use it routinely, read not at all well by comparison with good readers. It seems that there are no very good statistics; we certainly didn't have the time or money to gather a lot of information. Lacking conclusive evidence, I guess that the distribution curve is not at all Gaussian, but something like slowly rising to a peak which may be around 150 words per minute, and that this would cover a large part of the population. But to me it seems of the utmost importance that there is a significant part of the population which very much exceeds the performance of the majority. Now, why the hell is it that so many, as a matter of fact, the majority, don't even come close to potential? Well, one thought struck us when we ran our tests: the appearance of the reader's performance very clearly fell into two groups, and we got very quickly to where one didn't need a stop watch or anything to see directly whether an individual can read fast or not; just look at his fingers: .some explore character after character, I presume for geometry; by contrast others sweep with a constant steady movement. One may trust that these persons can read braille fast by their movements at the moment of observation, rapid or not. We almost invariably found in such cases, that even if a subject said he can read no faster than 150 words per minute and that he had tried it any number of times, we could crank our machine up and he conked out much higher, often over 200, sometimes all the way up to 320. This suggests that the pertinent difference here is whether somebody searches, like a seeing person would, for a geometry or whether he has learned to "look" for a readable pulsating sensation in his finger tips. I think, for one, we have to apologize to the blind: it is our faulty way of teaching them which causes the inefficient approach of many. Apparently it does not impress itself on many people that the method, what should one call it --the way the blind read, is systemmatically different from ours; therefore, we say, now look at these 6 dots; people even use cookie trays with ping-pong balls in them, things nice and large, you know, so the poor blind should have no problem grasping the spatial relationship; now if I put a ball in here and I put a ball in here, and one here, and one here -- lo and behold, this is a letter G. This basic approach continues throughout the teaching period and when the student is let loose and knows how to read braille, the poor guy really never understands it. That's not the way to do it. I feel strongly that the proper way is to use constantly moving braille characters to teach with; to move them slowly at first and progress to higher rates, but never even suggest that the information is tied to a pattern in space. It should, in my opinion, be firmly kept in mind that the information carrier is a pattern in time.

Well, presenting moving braille characters may be a subject which leads over to the design of the device we came up with after we had that preliminary study under our belts. One of the things we had to decide very early (because we couldn't make a whole arsenal of different machines) was how to display information. We started with the realization that we didn't find any code that showed great promise to be superior to braille so we said we'd stick to the latter. If somebody cannot learn braille or prefers to listen to taped speech, that is none of our business. We confine ourselves, if you will, to a specialized field; we are concerned with braille. We want to optimize the presentation or, as Prof. Mann of MIT said, enhance the availability of braille. So now, how to display it? Obviously, there are a limited number of modes or ways of how one can do it. One such mode may be called stationary, another one, dynamic, which means a stationary display would be one (like a page of braille on a table) which is there for the reader to do something with. On the other hand, a dynamic display would be, for instance, a set of characters moving under the reader's finger tips where the person just watches what's going on. You can, of course, make all sorts of combinations; for instance, a book is not really "stationary"; you turn the pages, and all that. There are other basic modes one can think of; let's take a line as an element. Now, what do we do with that? Do we display it in full length and after it's been read, it is removed, let's say, in an upward move and the next one appears, moving up, and it is read? That's one mode. The second one would be where you would move normal to the reading surface to present and remove characters formed, for instance, by rising and falling pins. Conversely you could have, as the principal, the basic mode of a dynamic display, a line which is really endless and just moves from right to left through a window, so that the sensation if you hold your fingers to the window is essentially the same as if you sweep the line on a stationary display with your fingers. I don't go here into all the combinations and permutations. We did try to explore possible modes somewhat systematically; and then we talked to a number of people, several of them blind, most of them highly intelligent, mostly good braille readers, and asked, "Which mode do you think you would prefer?" After that we built a device which allows to move a sheet of paper with embossed characters in different modes stepwise up, continually up, sideways stepping and continually, in various increments and with adjustable speed. It turned out you could read all of them, more or less. The only one that people couldn't read at all was the one for which the group's unanimous opinion had been that it would be the best. What they had wanted was several lines available at a time and kept in a steady upward motion so that one has a relatively large set of characters at any one time accessible --or whatever the reasoning was that seemed most appealing. But, as I said, this mode does not work; the sweep by the user's hand from left to right and the movement of the characters set from the bottom up left the user with no fixed reference, and he kept losing his place. So, we did some more tests especially with a line moving constantly from right to left with adjustable speed. Here you have a constant stream, as it were, of characters presented to your finger tips. It seems that from the standpoint of the reader, this mode was by far the most favorable one, and it turned out from an engineering standpoint also preferable to anything else; maybe it's just because we know how to do it or that we found out how to do it, but I think there is some systematic advantage in this mode.

We then designed a machine which contains a plastic belt which runs over a platen and recirculates around two pulleys. There are some funny mechanisms which do the writing and erasing of characters on this belt; a reader puts his fingers on the belt on the platen - and here we go! A sensitive trigger under the platen starts the transport, a selector provides different modes of operation (which we will discuss later), and finally there is a speed control for the operator to use. I just hold my fingers on the platen, and that's how I read. I can, of course, if I miss a character, move on with the belt a little, to spend a bit more time with each character; then, later on, I have to make that up by shifting my hand gradually back upstream. In short, there is some buffering available in a dynamic display even if one reads at any one time only one character; there is some flexibility. However, the average rate is adjusted to suit conditions by means of the speed control.

In answer to a question, I believe that to say one reads braille strictly sequentially is literally true. Now, there are individuals who use more than one finger simultaneously to gather information. Larry, for instance, does two things as far as I know. One, he reads part of the line with the left hand and part with the right hand, which partly eliminates the time loss attendant to line change and, anyway, he seems to like reading in this fashion. The other thing, he, as a braille reader, has to do is to keep track of the lines he moves on; he has to prepare to start the next line, to anticipate the jump from one to another. That is done with a second finger. But I have so far not met anybody who claims that he could read simultaneously with, say, two fingers on two lines. Another question is whether "sequentially" implies instantaneously. My guess is that this is not literally, but practically, true. Not only is the time of interaction of one dot with a finger very short, but the speculations outlined before indicate that all this may be accomplished with one firing of a neuron; in this sense I am inclined to call it "instantaneous." There may, however, be a few neurons stimulated in sequence, as a dot moves across a finger, especially if the latter is fairly thick. I do not know how such a signal would be processed if indeed it does arise; perhaps this has something to do with the impression of "fat" and "slim" dots in lieu of two and one dot patterns. In any case, however difficult the process appears when one attempts an analysis, people use it without appreciable strain. I know people that can read braille 8 hours in a row very, very effectively and not be any more fatigued than you and I would be in "deciphering" ink print.

Returning to the subject of the design of the braille machine: we said, let's write on an endless belt. But why do we want any machine in the first place? I mentioned that one of the disadvantages of braille is that not many people read it well and I said at least by implication that a machine with a dynamic display might help some of them to become better readers surreptitiously without being aware of it; indeed we found even in the preliminary screening experiments which I described that this can be true. I mentioned that people thought that they cannot read more than, say, 150 words per minute and yet they could; but we also found that the rate where somebody conked out, if he was a poor reader initially, drifted upward during the test - and we are talking of periods as short as 5 minutes; it drifted upward dramatically, which was a difficulty, by the way, in evaluating test results of low average subjects. The upper end measurements, on the other hand, turned out to be of an uncanny precision (which, by the way, to my knowledge with biological processes is a very rare good fortune). So maybe some people would be quick to adopt a better reading method, if one gave them machines; this remains to be seen. But, there is another disadvantage to the use of braille which one can attack with an appropriate machine, namely, the enormous bulk of braille reading material. On the average, the volume of a braille test is about 50 times that of corresponding ink print text; I say approximately because the ink print varies, of course, with character size, paper thickness, etc. A bound braille volume may be larger by two orders of magnitude. Now, that's bad. Imagine a blind high school student; even if he has parents that are reasonably well-to-do and interested in providing him with every possible opportunity; he can get enough reading material with the help of dedicated volunteers, but every closet in the house will be full of braille volumes, and the mail truck will bring more and more. Maybe he can squeak by. But most people just never have that chance. It's out of the question. Furthermore, not only is the method of embossing these magic little dots on paper cumbersome, but the price of such quantities of paper and binding becomes a very substantial factor. It is the central objective of this whole development --everything else is a fringe benefit --the central objective to get the bulk and the cost of braille down where it is manageable, where you can at least think in terms of literature being as available to a blind person as it is to a seeing person. I suppose asymptotically at least it makes sense now to think in these terms. Until very recently, it was absurd. How do we compress braille information by a factor of, let's say, 3 orders of magnitude for a start? The basic idea was lying around as usual. Not only does that seem a reasonable idea, but in our wanderings we confirmed that this is probably of the ideas presently and readily available to us the most practical one. The details tend to get a little involved, and I acknowledge gratefully the contribution of ANL's Applied Mathematics Division in working them out. Once we get into the electronic logic and control and the encoding of information, the computer people are the ones to work with. What do we need then in these terms? I don't propose to go into any details here, but, in principle, we have to get somehow magnetic domains on a tape and translate these into bumps on a moving belt. That is the description of the function or specification for a black box, if you will, which is needed. At the output end of this electronics package we have a group of six solenoids which are suspended to impinge on the belt. The problem then was to generate from a tape braille equivalent output to the solenoids. It can be done --with some difficulties! I just want to give you a few tidbits: Take 22 characters per second and an arbitrary amount of misalignment as tolerable (we have empirical numbers for that) of something like five one-thousandths of an inch for successful operation. Then it turns out that one has about 2 milliseconds for operating solenoids, which is "hairy," to say the least. Electronically it's a cinch, I suppose. But, it's not a cinch anymore with a magnetic coil with a moving slug of iron in it. That was one of the problems. The other one is timing: where do we get a signal that tells the electronics when to deliver the pulse after it is established what kind of a pulse we want? Furthermore once we started playing with this, we got ideas. One of them, for instance, is that, especially for a blind person, to find a specific subject in a whole book is even more difficult than for a seeing person. So, we said let's try to put indexing characters between the characters which refer to the braille text and somehow teach the machine to do some tricks so that it knows which is an indexing character and which is a book character and a couple of more things like this. Then, maybe, we could reel that tape off at high speeds, and as soon as the machine finds a preselected indexing character, it would stop and, low and behold, the reader has found his place. At least as far as, for instance, page numbers and such simple things are concerned, this has been successfully incorporated into the machine. This essay is not meant to provide a complete or systematic technical description or specification of the machine; rather let me just add a few more points. The size of the box into which it fits is about 12 x 9 x 3 inches, and the weight of the whole package is about 7 lbs. The logic and control module fits into the empty spaces around the other components in the box by cleverly packaging things. The power supply will be a separate package with a carrying strap; it will probably include some batteries so one can use the machine, for instance, when traveling for about 3 hours before recharging is necessary. Continuous operation will be from a wall outlet.

One should say a few things about the tapes which substitute for books or written material in the braille machine system. One of the ways of preparing such tapes is what might be called the classical one, namely, that somebody who knows Grade II Braille writes the text in that medium; there is no reason why one has to emboss braille symbols on paper; if you have a bunch of switches, for instance, with some keys and some simple electronics, one can write such symbols magnetically on tape. How does that compare with producing paper copy of braille literature? My guess would be that anywhere from about one-third to one-half of the literature available to blind people is still done by direct manual embossing. Other people emboss sheet metal plates in essentially similar fashion, from which one can run off copies by squeezing paper between these sheet metal plates. If you need enough copies, this becomes somewhat more economical or, rather, one should say less time consuming, because in the first case labor is usually contributed free of charge by volunteers; but the so-called press braille is nevertheless expensive. If only a small number of copies is required, one can make "thermoform" copies, vacuum forming plastic sheets over embossed paper sheets. All these mathods run to similar cost figures, if hand embossing is done by a volunteer without charge for the labor, i.e., if all you pay is the paper and plastic sheets for duplication. (The master sheet is almost always kept, so even if only one copy goes to a user, you have to make a duplicate.) This cost comes out around $50 to $100 a book. This is not an accurarate figure: the cost depends on a number of policy decisions and demand predictions. If you buy a book from a printing house for the blind, let's say, where the book is embossed with metal plates, the price would be in this ballpark, but if one would decide to make a book commercially with embossing plates and then find that only a small number of copies are required, let's say, between one and three, the cost could be as high as $2,000. Now, that is a sketchy picture of what braille tape has to compete with. Because its cost of material and labor for duplication is negligible by comparison, the tape system has only one major cost item to consider, namely, the labor necessary to make a master. Thus, it is automatically much more economical in all cases when this cost component divides in a fair number of copies required, without counting on volunteer labor at all for making braille tapes, to be very conservative. And one single copy of one title can be provided at a significantly lower cost in tape than on paper, due to savings in material, binding, handling and storage. Thus, the high end of the cost spectrum for braille tape is about where the low end of the present system is. Furthermore, we can do a number of things --there are some clever tricks one can play to bring the cost farther down yet. We hope that at least some of these will bear fruit. The most pessimistic assumption concerning braille tape would be that somebody has to type letter for letter what's to be put on tape and one converts this to Grade II Braille in a computer operation; it appears realistic that we can run even quite small numbers and most certainly large numbers of copies on 1/4 inch magnetic tape in this way for $1.00 - $100 per copy depending almost entirely on the demand volume.

Where are we in the development of the whole system? We have something that almost works. It still has a number of bugs, and especially some of the peripheral things don't work yet, or we think we know that they should work better than they do now. But essentially, I would say, we have the working model, and under a grant from HEW we will build 30 machines; we have only one of them under construction at present because we took the option to test one and then go ahead and build 29 more. So, we hope very much to place the order for the remaining machines very soon, and then we will have 30 machines to conduct a field test with. How we should organize a field test at this stage is under intensive discussion. In a recent meeting with HEW, we blocked something out which might save us about a year over the originally projected schedule. If one wants to play "crystal ball," I think we could be ready to deploy machines, if somebody is willing to pay for them, in something like two years from now; one could conceivably have machines in meaningful numbers in the hands of people in something like that. I hope that is conservative, but I can't guarantee it. As far as the production and distribution of tapes, the publishing end of the business, is concerned, my wife has come up with a suggestion which I believe merits very serious consideration; as a matter of fact, I am enthusiastic about it. I think that it is the right plan: Let's see whether the machines themselves can be subsidized, for instance by the Post Office, who then wouldn't have to carry truckloads, and I mean truckloads, full of braille books anymore, free of charge. So, they could, in order to get out from under this, say, "All right, we make a one time investment;* for the rest of his life we wouldn't have to carry a person's braille anymore, so we give him one machine free." Now, that's just one of the approaches I can think of; in any case, let's assume that people who have a reasonably believable need would get a machine without too much red tape; then, for the reading material the books on tape one may postulate that the blind users themselves would pay the cost and that they could do so, because we do hope that it will be possible to get the cost in the same range as that of ink print, by averaging. In other words, if somebody needs, let us say, a text on mathematical logic and there's one copy required and the honest cost of that, the incremental cost of producing that text on tape for him, let's assume, is $300; nobody else wants it; no further demand for the book is predictable. This, of course, one cannot very well average. But such a user would typically be a professional who could afford the true cost one way or another --or, let us say, he is a student with a scholarship or the like. By the same token, if we can run copies in large numbers for something like $1.00 apiece, I believe blind people would for the first time be interested; they would rush not only to read, but actually to buy, for instance, mystery stories. A blind friend keeps pestering me that he cannot get pornography under the present system and that this makes it very urgent to get the braille machine system going. What I am getting at is there will be markets, at least we postulate at this point that there will be many books sold in large quantities, where actually the cost is in the order of magnitude-- the incremental cost --of around $1.00. So, let's say these "paperback type" tapes are sold for $2.00 apiece if there are enough of them. That allows a not-for-profit publisher to mark low demand items down to a similar price, even though his actual incremental cost per copy may be, let us say, $50. The proposed idea, in a nutshell, is that it seems possible with the machine-tape system to simulate the price structure of the present book market by devising some appropriate formula for distribution of the overall cost of braille tapes.

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*We have reason to believe that in batches of, say 1,000, one complete braille machine could be made for around $500.

With this cheery note, I would like to close.

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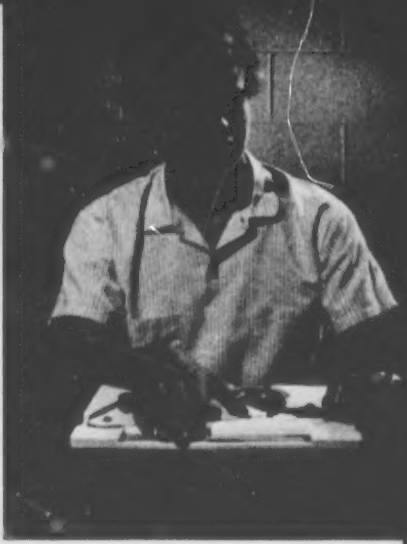

THE ARGONNE BRAILLE MACHINE

Under development in Argonne National Laboratory's Reactor Engineering Division is a device which may make obsolete the bulky and costly braille book and substitute for it a small reel of magnetic tape. A conventional braille book, embossed on heavy paper, is about 50 times as bulky as its inkprint counterpart. In contrast, a large book encoded on magnetic tape will require only as much space as a typewriter ribbon.

For the blind reader, the Argonne braille machine offers hope of a vast increase in the amount of literature available to him, and also the promise that reading will be less difficult.

The device takes symbols recorded on ordinary magnetic tape and converts them into patterns of upraised braille dots on a plastic belt that the device moves past the fingertips of a sightless person. He reads the symbols by touching the belt. The reader can adjust the speed of the plastic belt at will.

After the symbols move beyond the reader's fingers, the device "erases" the dot patterns (by depressing them) and raises new dots for the next pass. The belt is made of a special durable plastic that can be used for months before replacement is necessary.

With the braille machine and a plug-in keyboard, a user also can "write" his own letters, notes, etc., on magnetic tape, which can be played back on his own or on a correspondent's machine.

The Argonne braille machine promises another significant advantage. At present, translation of a single book into braille usually requires many weeks of work by highly trained specialists, which severely limits the amount of literature available to blind readers. When setting type for ordinary printed material, a tape is prepared from the manuscript; this tape is used to control a type-casting machine. Computers can be programmed to convert the code from available typesetters' tape to tapes for the braille machine, and this can be done quickly. Such magnetic tapes then can be reproduced and distributed inexpensively.

Through these innovations, the cost of reading material for sightless people can be cut to a small fraction of what it is now; a far greater volume and variety of literature can be made available.

Work on the braille machine was made possible by a 1967 amendment to the Atomic Energy Act. The amendment gave the Atomic Energy Commission authority to expand the range of areas in which Commission laboratories may work.

Argonne's capabilities in electronics, physics, and plastics applications, and the Laboratory's computers and computer programming skills, are contributing to the development of the braille machine. The work is funded by a grant from the U.S. Office of Education to The University of Chicago, which operates Argonne National Laboratory under a contract with the U.S. Atomic Energy Commission and the Argonne Universities Association.

A MAGNETIC TAPE BRAILLE MACHINE*

J. Hassl and W. Lidinsky, ANL T.M. 176, April 9, 1976

I. Introduction

Several methods presently exist for communicating information to the blind. The most widely accepted is the braille system. Braille characters are embossed on heavy sheets of paper which usually are bound to make up a book. The major disadvantage of this medium is the tremendous bulk of braille books, which occupy at least fifty times the volume of the equivalent inkprint material.

Another method is to record the spoken word on magnetic tape or discs. This approach suffers from a slow and inflexible speed in presenting the material. It also relegates the listener to a passive role.

Systematic limitations of the presently available methods point up the need for a new approach to the problem. What properties should such an approach have? Obviously, information volumetric density should be high and should exceed that of written books if possible (10^3 words/cm^3 or 4.3 x 10^3 characters/cm^3 is a design goal). The user must be able to absorb information at a rate suitable to him and not be restricted by the medium. The user should be active. Other desirable features are low cost, the ability to annotate existing text, and high-speed selective access.

In gaining these features, a new system should not become deficient in properties already achieved by existing practices. Skimming material and searching should be possible as they are with braille books. The user should be able to write in the medium.

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*This work is being performed jointly by the Applied Mathematics and Reactor Engineering Divisions under contract to the Department of Health, Education, and Welfare, and under the direction of Arnold P. Grunwald of Reactor Engineering.

Compatibility is important. Any new approach would have difficulty gaining acceptance if a massive retraining program were necessary to acquaint users with the new techniques. However, compatibility is restrictive. Serendipity is very useful when marrying new approaches to an existing framework.

A technique and a machine implementing the technique are described in this technical memorandum. The approach utilizes the existing braille system in combination with magnetic tape to achieve the aims of rate flexibility, high character density, and low cost, while maintaining compatibility. The sequence of braille characters is stored in a proper format on inexpensive 1/4-inch magnetic tape. A machine is used to convert the contents of the tape into embossed braille characters on an endless belt that moves under the fingers of the user. Provisions are made for varying the speed of the belt for the convenience of the user. Provisions are also made to back up and skim forward at will.

The system calls for extra interleaved character spaces on the magnetic tape. These spaces are reserved for annotation of the text by the user. The machine provides the user with the capability of writing braille notes into these spaces. The user may read either notes or text at his discretion. Because of the high character density of the tape, abundant space for notes can be allowed.

Index numbers can also be provided on any prepared tape. The user can cause the machine to move rapidly through the text looking for an index number just as a sighted reader searches for page numbers. The machine will automatically stop at a preset index.

Provisions are also made for typing braille letters onto blank magnetic tape. This tape may then be read back by the machine.

The hardware described consists of a specially designed magnetic tape transport capable of handling standard 1/4-inch magnetic tape, an assembly with a continuous movable belt onto which braille characters may be embossed, the read/write electronics for the magnetic tape, the embossing and erasing mechanism for the belt, and an electronic memory and control package. It is to be housed in a case similar to a standard sized attache case along with a battery pack, power supply, and battery charger. Cost of the package is to be moderate so as to make it possible for an individual to obtain a machine.

In the following sections, emphasis will be placed on the system approach, the electronic memory and control package, and read/write electronics. The tape and belt transports, their controls, and the embossing mechanism are covered separately.*

II. Tape Format

The Braille Machine will recognize three different types of characters: (1) book characters, (2) note characters, and (3) index numbers. These may be sequentially interleaved on the magnetic tape in any order (see Figure 1.

In order that the machine be able to differentiate between a character and its immediate neighbors on a magnetic tape, a bracket pulse (BP) is carried with every character. This pulse, in effect, tells the machine that a character has been read from the tape and is now in the machine in a specific location.

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*Developed under the direction of Arnold P. Grunwald of Reactor Engineering.

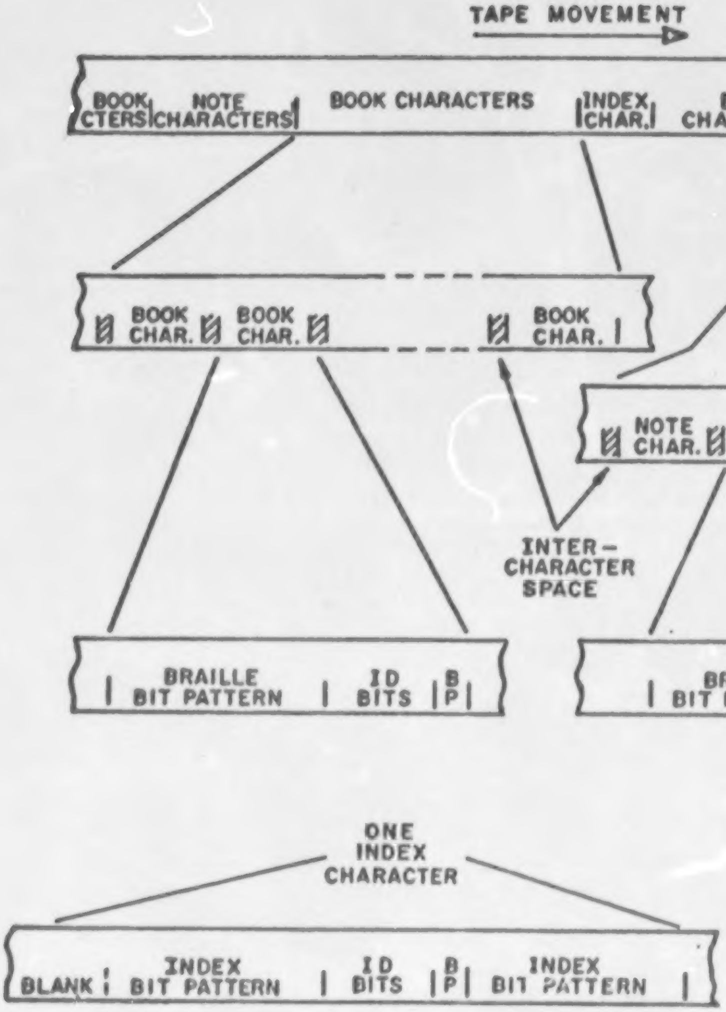
TAPE MOVEMENT
BOOK CTERS
NOTE CHARACTERS
BOOK CHARACTERS
INDEX CHAR.
BOOK CHARACTERS
NOTE CHARACTERS
BOOK CHARAC
BOOK CHAR.
BOOK CHAR.
BOOK CHAR.
NOTE CHAR.
NOTE CHAR.
NOTE CHAR.
INTER-CHARACTER SPACE
BRAILLE BIT PATTERN
ID BITS
B P
BRAILLE BIT PATTERN
ID BITS
B P
ONE INDEX CHARACTER
BLANK
INDEX BIT PATTERN
ID BITS
B P
INDEX BIT PATTERN

Fig. 1. Magnetic Tape Formats

172

Each character, in addition to having a bracket pulse, also carries with it identification bits. These bits define the type of character. They are used by the machine to make decisions about operation for any given character. For instance, if the machine is in the mode for reading only "book" characters, "note" characters and index numbers will be ignored. If, however, the ID bits define a book character to the machine, the braille bit pattern of the character is accepted and embossed on the reading belt.

In terms of the system, the only difference between book and note characters is that book characters may not be altered. Note characters, however, may be written over or erased at will. Erasure is accomplished by writing over with spaces.

A two-track/channel binary recording system is employed; in it the simultaneous contents of two tracks defines the bit pattern on the tape. This has two advantages: First, it allows self-clocking. This means that the recording redundancy is sufficient to provide clocking information that can be used to simplify the control logic. Secondly, by allowing three possible data combinations, it provides means by which bracket pulses and spaces may be defined (see Figure 2).

	(Blank) Space	Zero	One	BP
TRACK A	0	0	1	1
TRACK B	0	1	0	1

Fig. 2.

Bit Pattern Designation

In Figure 2, 1's represent the existence of a pulse while 0's represent the absence of information. Each braille character, when properly formatted, will require 10 bits of information. At a 660 bpi packing density, each character would require

$$\frac{10}{660} \doteqdot .015 \text{ inch of tape} \quad .$$

Since starting and stopping could occur between any two characters, an upper bound or the length of tape required for the transport to come up to speed or to drop to zero speed is (based upon start time = stop time = 5 ms and a tape speed of 1.5 ips)

$$(2) \times (1.5) \times (.005) = .015 \text{ inch} \quad ,$$

or the same amount of tape as the character itself. This figure, if constant acceleration is assumed, reduces to .0075 inch. This number could be further reduced by utilizing proper interleaving of character types.

Using 1.5 ips and .030 inch per character, further estimates can be made regarding information densities. With an average of 5.3 (braille) characters/word in a standard English Grade II Braille, a word occupies

$$4.3\ (.030) = .129 \text{ inch} \simeq 1/8 \text{ inch}$$

of tape (word packing density = 8 words/inch).

The mechanical system utilizes 3 ¼ inch OD reels and tape with a nominal thickness of 1.5 mil and a capacity of 5.4×10^3 inches/reel. Utilizing two channels (4 tracks), the total recording length is 1.08×10^4 inches. This is capable of storing

$$(1.08 \times 10^4) \times 8 = 8.64 \times 10^4 \text{ words/reel} \quad .$$

The volume of one reel and carton is about 94 cm^3. The word density is therefore

$$\frac{8.64 \times 10^4}{94} = 910 \text{ words/cm}^3$$

which is 91% of the design goal mentioned in Section I.

The 600 bpi initial assumption is conservative. Furthermore, proper character interleaving could eliminate much of the start/stop space associated with each character. Therefore, even with as much as 50% of the tape set aside for annotation, the desired density (which is equivalent to five to ten times that of inkprint books) can be achieved.

III. Hardware

Figure 3 is a block diagram of the Braille Machine. It consists of five parts as previously mentioned.

The magnetic tape and transport consists of the tape and an incremental tape drive.

The read/write electronics consist of the tape heads, the tape head amplifiers and a tape head switch that allows rapid switching between reading and writing modes.

The memory and control unit consists of shift register memories and the necessary logic to control the machine. Later, this portion of the machine will be described in more detail.

The keyboard is presently designed as a plug-in supplement to the main machine package. It could be a simple braille keyboard or a modified typewriter keyboard and encoder.

The embossing mechanism is a set of miniature solenoids driven by the memory and control unit and used to emboss braille characters onto the reading belt.

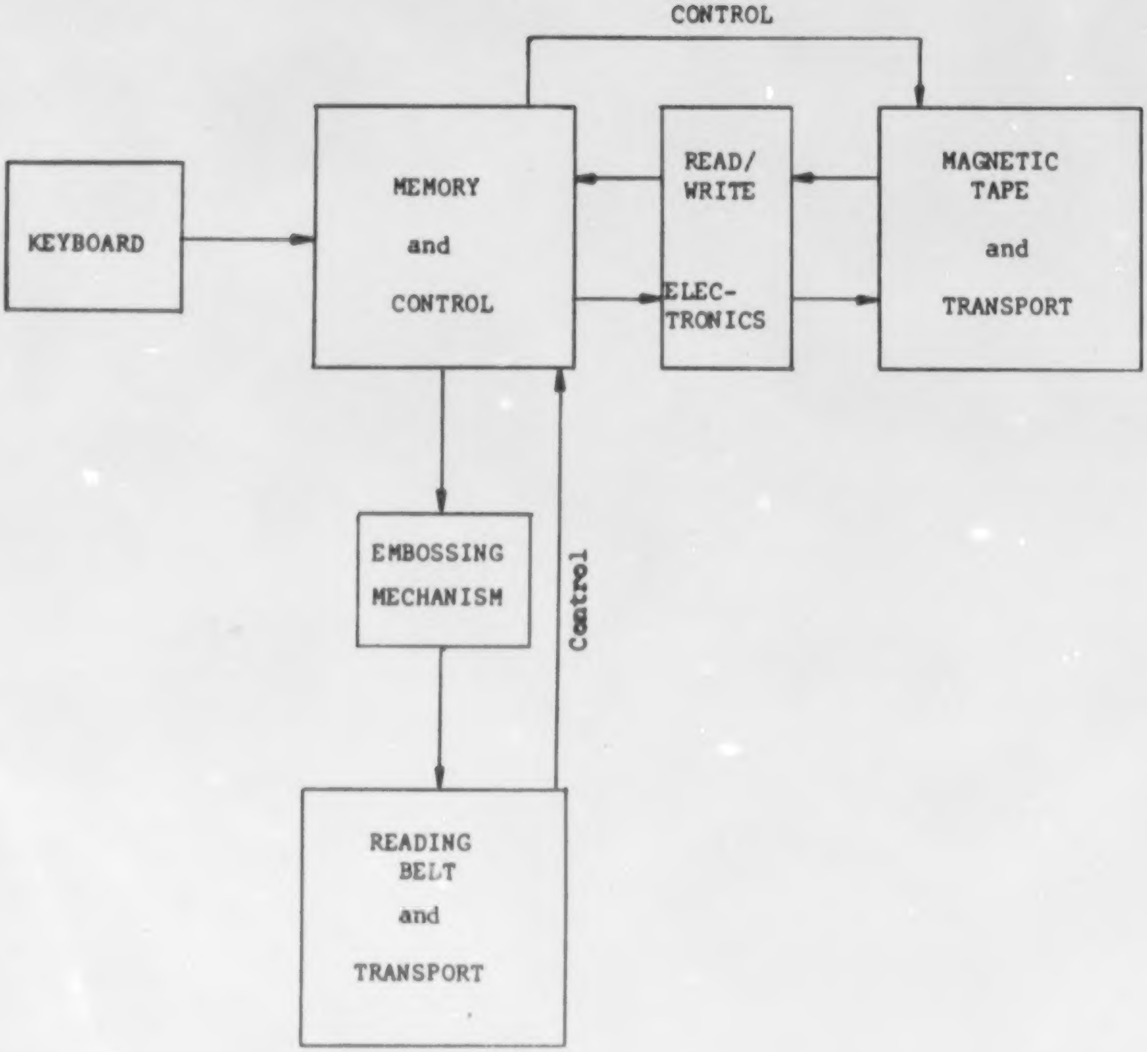
CONTROL
KEYBOARD
MEMORY and CONTROL
READ/ WRITE ELEC- TRONICS
MAGNETIC TAPE and TRANSPORT
EMBOSSING MECHANISM
Control
READING BELT and TRANSPORT

Fig. 3.
Machine Block Diagram

The reading belt and transport consists of an endless polypropylene belt and its attendant transport mechanism. The belt has small "bubbles" moulded into its surface. The "bubbles" are arranged in groups of six and are arrayed in the standard braille 6-point configuration. The "bubbles" exhibit a bi-stable property in that they are stable in the concave as well as the convex position. The user, keeping his fingertips on the moving belt, perceives only those "bubbles" which are "raised" (convex) in each group of six. The belt also contains a magnetic timing track which sends a timing signal to the memory and control unit whenever a set of "bubbles" is properly positioned over the writing assembly. In this way the Reading Belt is self-timing. This results in simplification in the control logic. After each pass through the window that exposes the "bubbles" to the readers' fingertips, all "bubbles" are erased (changed to the concave state).

Figure 4 is a detailed block diagram of the machine. Registers 1, 2, 3, and 6 together represent a transfer register capable of shifting in a bit serial fashion and transferring out bits in parallel. In effect, they are the heart of a parallel/serial and serial/parallel conversion scheme. These are the registers that receive data directly from the tape and that store the data just prior to writing on the tape.

Registers 4 and 5 are bit parallel, character serial registers capable of storing a number of braille characters simultaneously. These character registers alternately exchange roles in a manner such that reading and embossing or typing and writing may take place simultaneously. Thus, while Register 4 is outputting data to the belt, Register 5 can be accepting data from the tape via Register 2; or conversely, Register 5 may be in its output mode while Register 4 is accepting data. The Character Register Control determines the modes of the two registers and assures that they operate together without interference.

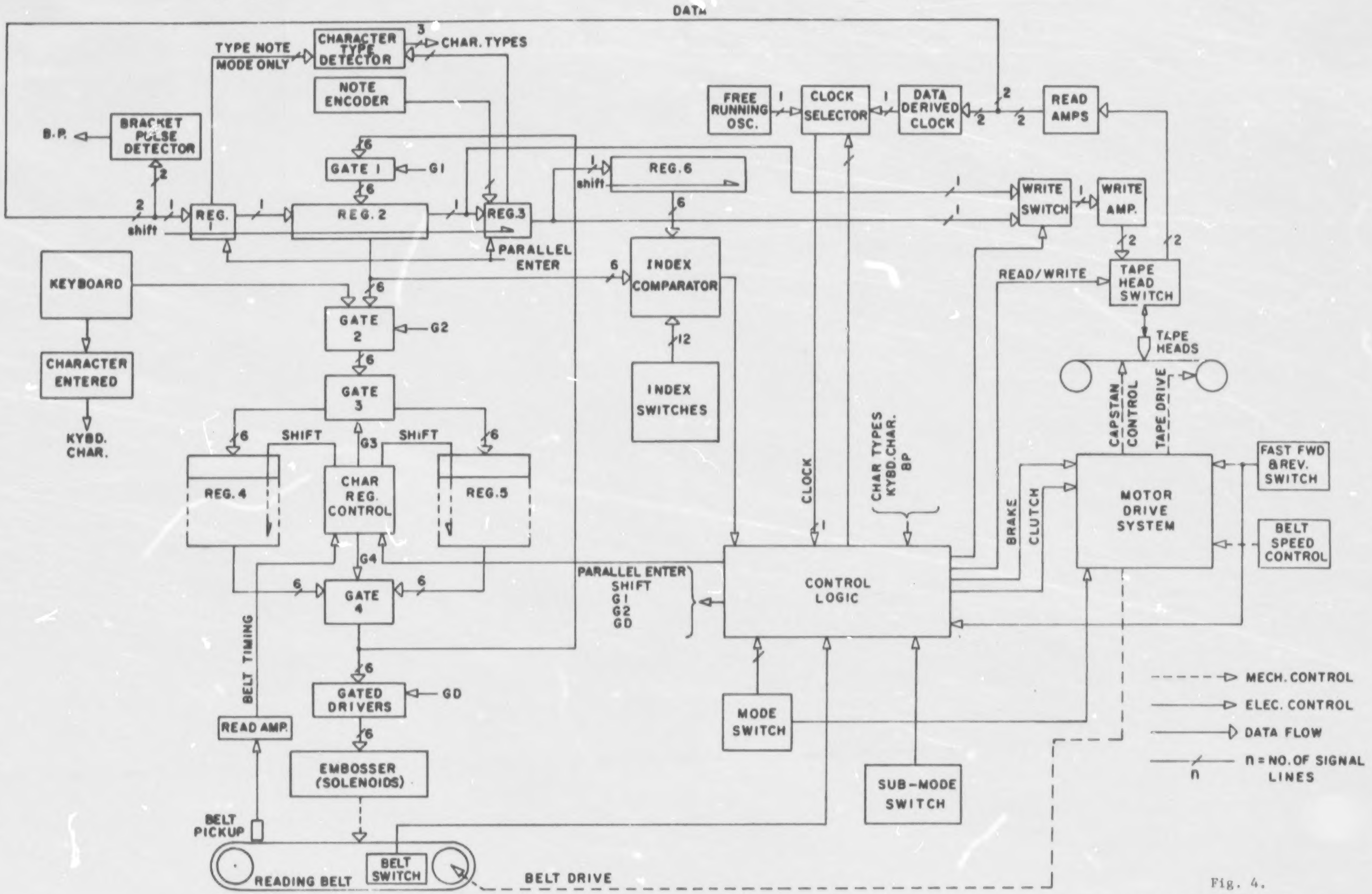
DATA
TYPE NOTE MODE ONLY
CHARACTER TYPE DETECTOR
3
CHAR. TYPES
NOTE ENCODER
BRACKET PULSE DETECTOR
B.P.
GATE 1
G1
REG. 1
REG. 2
REG. 3
REG. 6
shift
PARALLEL ENTER
KEYBOARD
CHARACTER ENTERED
KYBD. CHAR.
GATE 2
G2
GATE 3
G3
SHIFT
REG. 4
REG. 5
CHAR REG. CONTROL
G4
GATE 4
GATED DRIVERS
GD
EMBOSSER (SOLENOIDS)
READ AMP.
BELT TIMING
BELT PICKUP
READING BELT
BELT SWITCH
BELT DRIVE
INDEX COMPARATOR
INDEX SWITCHES
FREE RUNNING OSC.
CLOCK SELECTOR
DATA DERIVED CLOCK
READ AMPS
WRITE SWITCH
WRITE AMP.
READ/WRITE
TAPE HEAD SWITCH
TAPE HEADS
CAPSTAN CONTROL
TAPE DRIVE
CLOCK
CHAR TYPES KYBD. CHAR. BP
CONTROL LOGIC
PARALLEL ENTER SHIFT G1 G2 GD
BRAKE
CLUTCH
MOTOR DRIVE SYSTEM
FAST FWD & REV. SWITCH
BELT SPEED CONTROL
MODE SWITCH
SUB-MODE SWITCH
MECH. CONTROL
ELEC. CONTROL
DATA FLOW
n = NO. OF SIGNAL LINES
n

Fig. 4.
Braille Machine Detailed
Block Diagram

This scheme has two advantages. First, it allows the Reading Belt to operate in a "smooth" manner. If a split buffer were not used, data would have to be alternately read from tape and then embossed onto the belt. This could result in the Reading Belt moving in a halting manner at high reading rates (300 wpm or 47 ms/char.) since it will take about 85 milliseconds to read in eight braille characters, assuming no interleaving of character types.

The second advantage stems from the fact that without buffer storage, the magnetic tape would have to start and stop on every braille character. This action must be considered when designing the Motor Drive System. With buffering, the number of starts and stops is reduced in proportion to the capacity of the buffer. This reduces the wear on the drive mechanism.

A clock selector may select either a free-running oscillator or a data-derived clock. The data-derived clock generates clock pulses from the data being read off the magnetic tape. As was pointed out previously, the data format has sufficient redundancy to allow this to occur. In the case where the user wishes to write on blank tape, no data exist, and a free-running clock is necessary.

The Index Comparator compares the contents of Registers 2 and 6 with the contents of the Index Switches. In the search mode of operation, equivalence of these data will automatically stop the machine.

The operator controls are the mode switch, the sub-mode switch, the fast forward/reverse control, and the belt speed control.

The belt switch is a micro-switch under the reading belt. During read operations whenever the user's fingers are on the belt, the switch will be activated, and the machine will be reading and embossing if the mode switches define a reading operation. During fast forward or reverse or search operations, the Reading Belt will be stationary. To activate a search operation, the user sets the index selector to the desired index, and the mode switches to search and then touches the Reading Belt momentarily. The machine will latch into the search mode until coincidence occurs. During writing operations, the belt switch is inactive.

The mode switches select the type of operation the machine is to perform (i.e., searching, slewing, reading book characters, reading note characters, typing notes, or typing manuscripts).

The belt speed controls the rate at which the belt moves under the user's fingers and consequently indirectly controls the rate at which information is read off magnetic tape.

A detailed discussion of the manner in which this machine performs its various mode functions is covered in the following section.

IV. Operation

The Braille Machine is capable of six modes of operation as follows:

A. Automatic search for index numbers in properly formatted book tapes.

B. Reading of book tapes.

C. Reading of notes written into book tapes.

D. Typing of notes on book tapes.

E. Typing of manuscript on blank tape.

F. Fast forward and rewind to a desired tape location under the reader's control.

Modes A and F are actually as one and differ only in the setting of the Index Switches. Modes B and C are both reading modes. Differentiation between them is made by the Sub-Mode Switch. Typing Modes D and E are similarly treated.

The following sections discuss these modes of operation. Reference should be made throughout this section to the Braille Machine block diagram (Figure 4).

A. Automatic Search

The mode switches are set to the search position. This programs the drive for fast continuous tape transport and the logic for index number searching. The desired index information is entered into the index switches. These switches initially will be thumbwheel switches with braille characters embossed on their face. The Reading Belt will not be in motion.

The control logic will put the Tape Head Switch in a read mode; control signals G1 and Parallel Enter will be inhibited, preventing parallel input to Registers 2 and 3; output to the Reading Belt will be inhibited; the Character Type Detector is set to look at Register 3.

The magnetic tape moves at the slow rate. Bits from the tape are shifted serially into Registers 1, 2, 3, and 6. When the bracket pulse and ID bits associated with an index character reach Register 3, they are viewed by the Character Type Detector. Simultaneously, the Index Comparator is comparing the contents of the Index Switches with the contents of Registers 2 and 6. When the contents of the Index Switches matches the contents of Registers 2 and 6 and when the Character Type Detector defines the character of Registers 2 and 6, as an index number, the tape transport is stopped.

B. Reading of Book Tapes

The mode switches are set to read book characters. This programs the unit for reading book type characters in sequence from a book tape. The

Tape Head Switch is in the read mode. Tape movement is forward at the read/write speed. Starting and stopping the tape drive is under control of internal logic which in turn is controlled by the Belt Switch. The Reading Belt is in continuous motion. The Data Derived Clock is selected, and parallel input into Registers 2 and 3 is inhibited. The Character Type Detector interrogates Register 3.

To begin reading, the reader places his hand on the Reading Belt, activating the Belt Switch. The following is a sequence of the operations that will occur during reading:

a) The tape begins to move at the read/write speed, and the Reading Belt begins to move under Belt Speed Control.

b) Bits from the magnetic tape are shifted serially into Registers 1, 2, 3, and 6.

c) When a bracket pulse (BP) and "book character" identification bits occur in Register 3, the contents of Register 2 are transferred into either Register 4 or Register 5. Return to (b) if this register is not yet full. If it is full, go to (d).

d) Check the status of the other character buffer register. If it is not yet empty, it is busy outputting data. Stop the magnetic tape drive and wait. If it is empty or when it becomes empty, put the character buffer register described in (c) above into its output mode under belt timing control. Simultaneously, put the other register into its input mode and start the magnetic tape drive. Go to (b) _and_ (e). (It must be pointed out that two things will be occurring simultaneously; the loop starting at (b) and continuing to (d) and a loop starting at (e) and continuing to (f) will function at the same time.)

e) Begin to shift the contents of the register that is in the output mode, one character at a time, to the Reading Belt. This shifting is under Belt Timing Control.

f) When the register becomes empty, stop outputting data and wait.

C. Reading of Notes

The reading of notes is identical to the reading of text except that the mode switches are set to read notes, which causes the unit to operate on note characters rather than book characters.

This mode is also used for reading manuscripts, since manuscripts are actually sequences of note characters.

D. Typing Notes

Notes may be typed onto a book tape. In doing so, it should be remembered that a book tape has been prepared with note identification bits and clock bits.

The mode switches are set to type notes. This programs the unit for writing note characters on the previously described prepared book tape. The tape movement control moves the tape forward at writing speed, starting and stopping is under control of the logic. The Reading Belt is active and will contain current information that has been typed. The Data Derived Clock is selected and input into Registers 4 and 5 from the keyboard is enabled. This is done via Gates 2 and 3. The output of Registers 4 and 5 is connected to Register 2 via Gate 1. The Character Type Detector interrogates Register 1. The Tape Head Switch under control of the logic is initially in the read mode.

The user then starts typing. The following is a sequence of operations which occur during typing:

a) Characters from the keyboard are entered into Register 4 or 5 (whichever is in the input mode). The register is shifted on each character.

b) When the register becomes full, the status of the other character register is checked. If it is not empty, the input is inhibited and the machine waits. If it is empty, or when it becomes so, the full register is switched to output mode and the empty register to input mode.

c) Go to items (a) and (d), simultaneously.

d) Start the magnetic tape at the read/write speed.

e) Bits from the tape are shifted serially into Registers 1, 2, 3, and 6.

f) When a bracket pulse and a "note character" ID code exist simultaneously in Register 1, one character from the full register is shifted to Register 2 and simultaneously embossed on the Reading Belt.

g) The Tape Head Switch is set to write from Register 2.

h) The contents of Register 2 is shifted out in a bit serial fashion, writing the character onto the magnetic tape.

i) The Tape Head is switched to read. If the output mode register is empty, stop the magnetic tape and wait. Otherwise, go to (e).

E. Typing Manuscripts

Typing manuscripts will be similar to typing notes except that a completely blank tape can be used.

The mode switches are set to the manuscript typing position. This program the unit for writing characters onto a blank tape. The Tape Head Switch is set to write from Register 3. Magnetic tape movement is forward at writing speed. The Reading Belt is active and contains recently typed characters. The free-running oscillator is selected as the clock, and parallel input into Registers 4 and 5 from the keyboard is enabled. The output of Registers 4 and 5 is connected to Register 2 via Gate 1. The Character Type Detector is not used.

To start, simply start typing. The following is the sequence of operations:

a) Characters from the keyboard are entered into Register 4 or 5. The register is shifted one character for each entry.

b) When the register becomes full, the status of the other character register is checked. If it is not empty, the input is inhibited, and the machine waits. If it is empty, the full register is switched to output mode and the empty register to input mode.

c) Go to (a) and (d) simultaneously.

d) The magnetic tape is started at writing speed.

e) One character from the non-empty register is shifted to Register 2 and simultaneously embossed on the Reading Belt. Register 3 is loaded with a bit pattern for note characters and a bracket pulse.

f) The contents of Registers 2 and 3 are shifted out in a bit serial fashion and written onto the blank magnetic tape.

g) If the output mode register is empty, the magnetic tape is stopped and the machine waits. Otherwise, go to (e).

V. Comments

The marriage of magnetic tape and braille characters requires that each user have a machine such as the one described in this paper. It is, therefore, desirable that this machine be inexpensive, small, portable, and simple to operate. Obviously, these objectives are sometimes in contradiction, and compromises are necessary. Sometimes operational simplicity can be achieved only by machine complexity. This is especially true as the versatility of the machine increases. Consequently, extensive evaluation of the machine will be necessary in order that the compromises made may be in some manner optimized.

An area which looms as a problem unto itself is the preparation of properly formatted 1/4-inch magnetic tapes, which contain braille translations of source material. In order for a machine of the type described to be useful, tapes must be available (in the very broadest sense of the word). Computer programs exist for translating source material into braille; The American Printing House for the Blind, IBM, Massachusetts Institute of Technology, and others are working in this area. These programs variously utilize paper typesetting tapes and punch cards in different formats as input. The typesetting tapes seem particularly desirable since they are are used in the production of much printed matter and are therefore available without additional expenditure for the braille system. Figure 5 is a likely flow diagram for the whole system from printed source material to "bubbles" on the reading belt.

The major task in providing reading material (tapes) for Braille Machines, once they are available, will be to organize production and distribution of tapes efficiently and respond to the demands and needs of the individuals or groups of users.

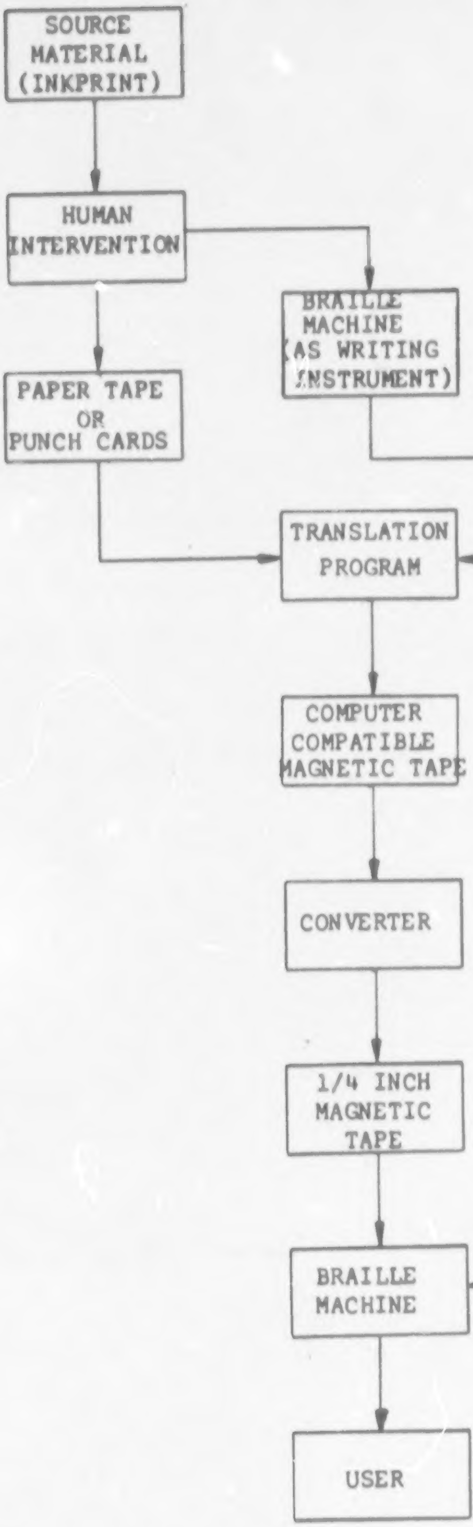
SOURCE MATERIAL (INKPRINT)
SOURCE MATERIAL (MANUSCRIPT)
HUMAN INTERVENTION
BRAILLE MACHINE (AS WRITING INSTRUMENT)
TYPESETTING TAPES
PAPER TAPE OR PUNCH CARDS
TRANSLATION PROGRAM
COMPUTER COMPATIBLE MAGNETIC TAPE
CONVERTER
1/4 INCH MAGNETIC TAPE
BRAILLE MACHINE
USER

Fig. 5.
Overall System Flow Diagram

ON READING AND READING BRAILLE - A. P. Grunwald

Proceedings Braille Research and Development Conference,
sponsored by Sensory Aids Evaluation and Development Center,
M.I.T., 1966

This presentation is going to be disorganized, because I have not yet written the paper. It is therefore cunningly called a preview.

Nevertheless, I ask you to bear with me for a few minutes so that I may have the benefit of a critical discussion of the material I want to talk about.

We have recently conducted a series of experiments with the purpose of better understanding the braille reading process. The primary objective of this work was to establish criteria for the design of a braille reading machine; a report on this effort has been published in SCIENCE, the October 7, 1966 issue. However, what I would like to discuss with you now concerns certain more general conclusions which perhaps can be derived from our results.

But before we discuss conclusions, let me first very briefly describe what we did: A device was constructed which moves sheets of paper embossed with braille characters over a platen, either continuously at precisely controlled rates or in accurately timed steps; in the second case, the paper is at rest between the feed movements.

In this fashion the reader was presented with lines of braille, which were either moved mechanically under his fingertips or scanned by his fingers while the sheet was at rest.

In order to avoid interference with the measurements by factors such as memory or mental manipulation of words, we wanted the reader to pronounce the words he read as he read them and to prevent him from anticipating words. Therefore, we used mostly sheets with randomly selected words (rather than with whole sentences); to provide sufficient time for pronunciation, extra blank spaces were left between words.

With this method we obtained accurate and consistent rate measurements but how is the rate measured correlated to the speed of actual reading? Fortunately for us it turned out that the relationship is simply one to one.

This relationship was established as follows: We asked several braille readers first to read a page which we had picked from a high school biology text, without vocalization or subvocalization, word for word, as fast as they could. The same readers took then the pronunciation test outlined before. Finally we presented the subjects with meaningless binary dot patterns (such as dot/dot, dot/blank, etc.) and determined the maximum speed at which the subjects were still able to perceive the presence or absence of the dots, spaced at the distances of braille dots.

The most interesting result of this program seemed to us the fact that reading, word pronunciation, and dot resolution tests yielded the same number for maximum sweep rate for all subjects with reliable scores. Not only did each subject score alike on all three tests, but, to our surprise, different subjects also had the same score. Furthermore, this score is interesting in itself: the maximum sweep rate turned out to be 13.8 cm per second, equivalent to 22 braille characters per second or (according to a statistical analysis of the texts used) to $\sim$ 320 words per minute.

I now can turn to certain conclusions based on these data which I would like to discuss with you, which concern the reading process in general, rather than specific engineering problems, which had originally motivated the experiments.

As a first conclusion I offer that the identity of sweep scores on the three different tests indicates that pattern recognition in reading is not correlated to comprehension. Strictly speaking, this has been demonstrated only for braille reading, but it is tempting to see what happens if one generalizes the postulate.

I realize that this postulate-- even limited to braille only --seems to fly in the face of everyday experience: we all slow down as soon as we become unsure of the meaning of what we are reading. Or do we? Could it be that in this case we do not slow down so much but rather read intermittently? I do not want to clutter this overview with details which lead me to believe that this actually is the case; it is sufficient to say that the apparent contradiction may perhaps be resolved by this interpretation.

If the postulate holds, it would be significant for several important matters, such as teaching, reading techniques and perhaps even for printing and other subjects. I propose therefore that it would be worthwhile to investigate this matter more extensively.

Another interesting finding is that the maximum recognition and resolution rates are not only alike for one subject but for several persons, in fact for all those in our sample who scored above ∿ 200 words per minute. This looks to me pretty much like a time-dependent neurological phenomenon, which might for instance explain the finding of other researchers that reading speed seems hardly correlated to increasing size of braille characters. At any rate we are presently attempting to illucidate the nature of the apparent constant.

The second conclusion we propose is that braille reading, done skillfully, is a dynamic process, that is, that the reader perceives patterns in time rather than in space or that he is concerned with rhythm rather than with geometry. Here are my reasons for this postulate: First it seems easier to reconcile a reading rate of 22 characters per second with dynamic concepts rather than with geometry. More important, impressions on the nerve endings of the fingertips must change constantly as dots and fingers move steadily relative to one another. That this relative motion is indeed steady is borne out by the fact that when we mechanized the scan (and had the reader's fingers held steady), no change in reading rate occurred relative to normal reading with deliberate scanning motions. Finally we found that at the sweep rate of 13.8 cm per second the 3.75 mm intercharacter dot distance is just barely resolved, whereas the 2.5 mm distance between dots within a character is not. Thus, if the reader would need to grasp the "real geometry" of the character in order to understand it, he would have to infer it not only from a moving impression, but also from one which is further modified or distorted by apparent fusion of dots within a character at higher reading rates. We doubt that such a complicated translation process is actually involved in braille reading, but even if it were, the primary impression on the reader must be continually changing; it cannot be a static one in the light of our findings; it must be in this respect systematically different from what is taught about visual reading.

This would seem to call for some re-evaluation for instance in our techniques in teaching braille. For example,to introduce beginners to a peg board or other stationary geometrical pattern to teach him the appearance of braille characters is probably a detour; worse (at least to my knowledge) no methods have been developed to help him make the transition to "dynamic" reading, but he is left to make this transition by trial and error development on his own; he is not even directed to focus on the problem he faces in this development; instead his attention is originally directed toward static patterns, and that is where the matter rests. The result is that few readers develop a smooth sweep and are severely handicapped in their reading speed. The actual relationship is borne out not only by our experience that it is possible to make a fair guess at a subject's reading speed simply by observing how smoothly he sweeps the line. Furthermore, we found that average and poor readers show an immediate increase in reading rate when the sweep is taken over by our test device and thereby made even, in spite of the fact that this results in (at least to them) somewhat unfamiliar sensations.

Perhaps better understanding of how the written material appears to the reader and how he interacts with it could generally be profitable. Is, for instance, the often repeated statement that the eye reads only during "fixes" sufficiently demonstrated and, more important, what does it mean? How do we achieve continuity in this process; that is, how do we avoid overlapping of fixes and/or redundancy of information or breaks in continuity?

In short, it seems to me that we tend to think about and teach braille as if it was to be seen rather than felt; and I am not even sure that I have an adequate understanding of how we manage to read a printed page visually.

A Braille-Reading Machine

Arnold P. Grunwald

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A Braille-Reading Machine

Abstract. *A new system for publishing and presenting Braille text is delineated. The system requires a new device for actual "reading." Experiments to determine reader preference and acceptance of the device are presented, and performance criteria on the device are listed.*

Braille is an internationally successful method of reading for the blind. Trained readers find it easy to use, and many consider it more satisfactory than auditory substitutes. However, Braille does have some drawbacks: (i) publication has, until recently, required the intervention of a human translator; (ii) the volumes are expensive to produce, ship, and store; and (iii) each volume is very bulky. The relatively low number of volumes produced and the bulk of each volume account for the high cost and limited use of available Braille material.

With modern computers the translation of standard text into higher grades of Braille (that is, Braille spelled with standardized symbols for groups of letters or whole words) is possible without human intervention other than that needed to prepare the text for the computer (*1*). The growing use of coded paper tapes in the typesetting used by industrial printers has aided in the preparation of material suitable for computer input.

Problems of cost and bulk remain if computer translation is used only to produce conventional Braille sheets with embossed characters. It is not practical for one to acquire a library of these Braille volumes, as each volume occupies at least 50 times as much space as its corresponding ink-print volume.

Contemplating the automation of the Braille translation process, we have been impressed by the low cost and the compact method of storing the information on magnetic tape. It thus only seems logical to include these features in the publication and storage system of such a process. Therefore, we are led to consider methods for translating the magnetic tape into Braille text at the time and place of reading. What is needed for such a procedure is a machine for reading Braille text. We present information on the required properties of such a machine (in advance of completion and testing of a prototype) in order to inform others who may be working along similar lines. The utility of such a device seems to justify the technical impropriety.

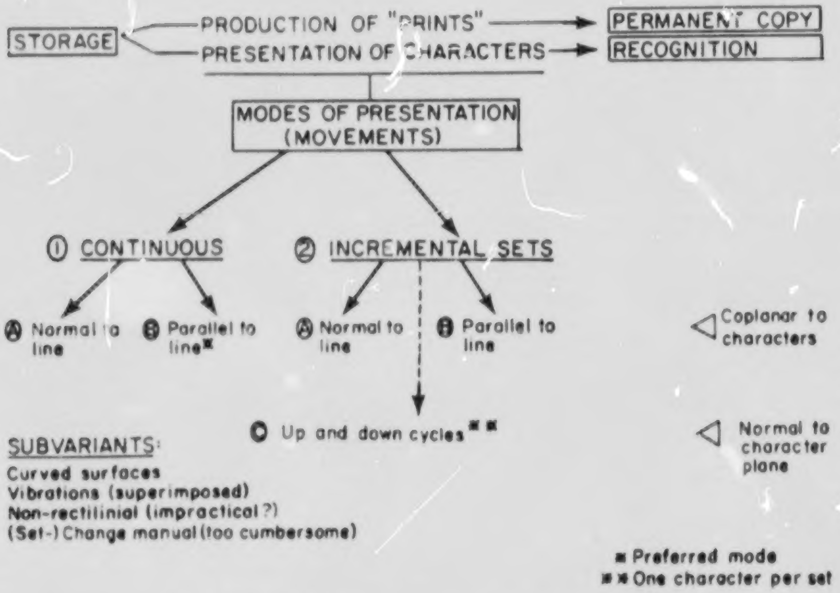

Fig. 1. Modes of presentation of characters to a reader.

Three requirements had to be examined before any preliminary design could be attempted. These requirements (reaction of the reader, acceptance by the reader, and speed of presentation) concern the manner in which the raised Braille characters are ultimately presented and the speed of such presentation. The first feature to be considered is the reaction of the reader to the replacement of permanent printout with mechanized display. In addition to the obvious desire to discourage the production and storage of bulky objects, we believed that with little training greater reader comfort would follow the elimination of page handling.

The second requirement, acceptance, is expected to depend on the feature of presentation we have called "mode." Mode concerns the way the raised characters become accessible to the reader, and the direction and timing of corresponding movements. We use the term "A mode" to describe presentation of whole lines (with one or several lines at a time available to the reader). In the A mode the upward motion of the text assumes the role of the conventional downward scanning motion of the reader's hands on the Braille page. In what we call the "B mode" only a single (essentially endless) line of text is presented, and the line moves sideways, corresponding to scanning a single line by hand movements. In addition to the choice of direction, there is a choice of stepped or continuous presentation of information. In continuous modes (option 1) the flow of reading material proceeds continuously. In stepped modes (option 2) material is rapidly presented to the reader, is permitted to remain available for a period, and is then replaced by new material. The last requirement that had to be determined was speed (characters presented per unit of time).

Modes A and B and options 1 and 2 can be combined to describe four modes. (i) Mode A.1 consists of several lines moving continuously upward as the reader scans each line from left to right. (ii) Mode A.2 is the same as mode A.1 but with the upward motion stepped. (iii) Mode B.1 consists of a single line flowing past the reader (right to left) while the reader's hands are essentially stationary. (iv) mode B.2 is the same as mode B.1 but with sideways motion stepped and the reader scanning each stationary line from left to right. The many possibilities of presentation may be seen in Fig. 1.

Initial prejudice of the Braille readers whom we consulted was for the A.1 mode, which they expected to be most similar to page reading. However, we thought it necessary to get more conclusive evidence, in view of the fact that the B modes (especially the B.1 mode) hold promise for a machine of much less complex design. A testing device was built (Fig. 2). This device consists of two rolls between which a sheet of paper can be fed. Each roll is equipped with two independent drives, one for continuous rotation (adjustable over a wide range of speeds), and the other for achieving feed in steps of either 10 mm (interline Braille spacing) or 230 mm (width of a Braille page). Two interchangeable cover plates with rectangular cutouts were used; on one the long axis of the cutout was parallel to the direction of travel, and on the other it was normal to it. The paper fed into the machine was embossed with Braille characters which were available to the reader within the field defined by the cutouts. Proper selection of drive mechanisms, cover plates, and test sheets of Braille enabled us to test read in the four modes described above. For the most part, the reading material used consisted of single words of controlled length (in terms of Braille characters per word), arranged in such a way that one word was not related to the next by alliteration, spelling, or similarity of meaning. Empty spaces were left between words on the test sheets. The inclusion of these empty spaces was necessary to permit pronunciation. Rapid speech was still slower than fast Braille reading by a factor of two.

These test sheets were presented to readers who pronounced the words aloud as they were presented to them at various rates. Reading speed was defined as the number of characters and blank spaces which the reader could sweep (per minute) while pronouncing 95 percent of the words correctly.

This method of testing was used in preference to subjective testing to avoid having fast readers get the meaning of a sentence by skimming rather than really reading every word, and to eliminate factors such as memory from interfering with the measurement of reading speed. However, such an interpretation of reading rate requires verification. For this purpose three subjects, all fast readers, were asked to read silently (that is, without vocalization or subvocalization) a page of Braille (descriptive text from a high-school biology book) as quickly as possible. Their maximum speeds agreed with their maximum speeds in the pronunciation tests. We also used some test sheets which consisted of randomly spaced dots presented in the B.1 mode. The speeds at which the presence or absence of each dot could be recognized were determined. For fast readers the recognition speed corresponded (in terms of finger sweep rate) with the maximum reading speed.

Tests were then performed on ten subjects of both sexes, ranging in age from 12 to 52 years, and varying with respect to years of education received from grade school to Ph.D.; their Braille reading speeds ranged from 60 to more than 300 words per minute. Adjustment to living as handicapped persons was good, and in some cases extraordinary. All readers found the A.1 mode unacceptable. The best readers were ultimately able to cope with it, but found it tiring and unsatisfactory, their speeds having been greatly reduced when compared with other modes. Good readers (200 words per minute) and excellent readers (300 words per minute) showed consistent

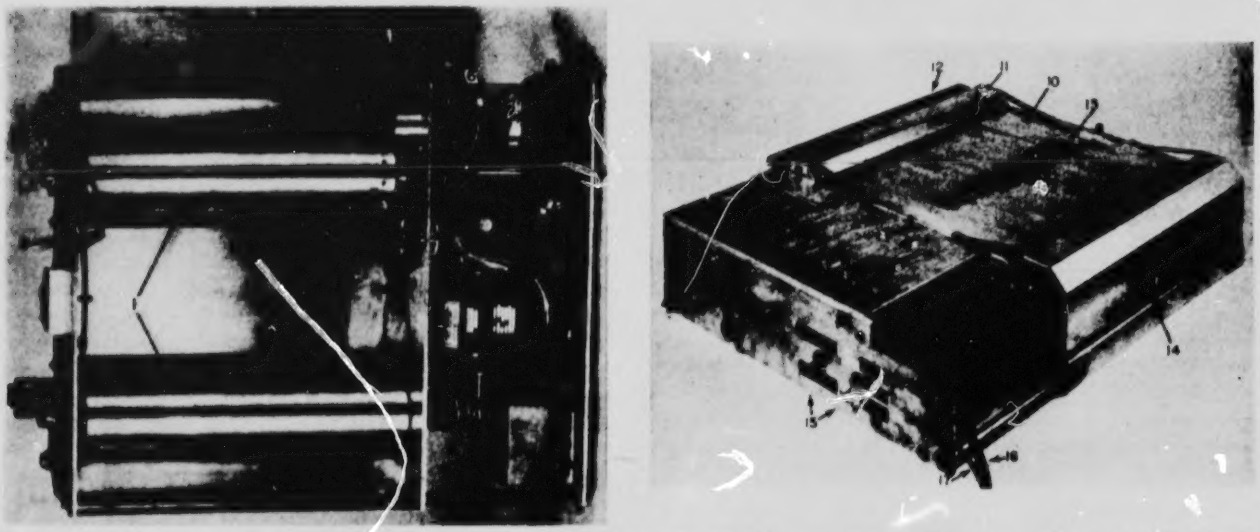

Fig. 2. A Braille-reading device. (Left) Bottom view with parts labeled. (Right) Top view of the device, ready for loading, with parts labeled. (*1*) Feed rolls; (*2*) motor for continuous rotation; (*3*) unidirectional clutch (for 10-mm steps); (*4*) solenoid (for 10-mm steps); (*5*) single-revolution clutch (1 revolution = 230-mm feed); (*6*) clutch trigger solenoid; (*7*) escapement (10 mm); (*8*) brake; (*9*) socket for (external) adjustable time switch; (*10*) cover plate; (*11*) roll guard; (*12*) paper release bar; (*13*) cutout (A-mode cutout shown); (*14*) paper exit chute; (*15*) mode-selector switches; (*16*) cable leading to motor speed control unit; (*17*) power-supply cable.

reading speeds in all modes but A.1. In the A.2 and B.2 modes there appeared to be about a 10 percent reduction in maximum reading speed as compared with the B.1 mode. Perhaps this is the result of the need to sweep back to the left margin after each line is read. Fair readers (100 to 150 words per minute) and poor readers (less than 100 words per minute) had even more pronounced preference for the B.1 mode than did the superior group, and, in fact, some of them achieved much higher rates with it than they did with the usual Braille text.

It thus appears that the B.1 mode, which we had considered desirable for engineering reasons, is preferred by readers. To substantiate our conclusions we asked each reader for comments on the B.1 mode. (Unfortunately, we revealed our prejudices for certain modes.) There was unanimous agreement that it was acceptable, and probably easy to adjust to. Several hoped that use of such a mode would improve their reading speeds (the B.1 mode has some features akin to those that are used in training for speed reading, and many thought that it might improve their reading comfort and enjoyment.

At this point we prepared the following set of criteria for a Braille-reading machine. (i) The machine should be conveniently portable. This implies at least an optional battery operation, and a weight of approximately 4.54 kg. (ii) The machine should be inexpensive. An estimated production cost of less than $500 should put it within the financial means of professionals. There are approximately 380,000 blind or severely visually handicapped people in the United States. Let us assume that one out of eight in this population reads Braille intensively when Braille reading material is more widely available. Free distribution of reading machines to those who need them would then entail expenditure of approximately $25 million—not an excessive amount by government or foundation standards. (iii) The machine should be durable, with simple and convenient controls, and should require standard supplies such as batteries. (iv) Presentation of material should be in the B.1 mode, and the characters should be erased after they have been read. (v) The machine should allow the magnetic tape to move quickly forward and backward, permitting the reader to locate any desired page or passage of text easily. (vi) The code used on the magnetic tape should be producible as direct computer output. It should include pagination, indexing, and cueing features for the reader. (vii) The tape (including box and reel) should contain at least 1000 words per cubic centimeter of space it occupies to make the system competitive with ink-print volumes. (viii) The maximum rate at which the machine presents characters should exceed 22 characters per second. (Three of our subjects routinely achieved this remarkable speed.)

In addition to these requirements, certain accessory features would be highly desirable with regard to the use of the machine for writing and annotating. With the addition of a device incorporating a Braille typewriter keyboard it should be possible to type directly onto magnetic tape. A blind author could then have his text translated into standard print by means of a computer. More commonly, it would simplify his letter writing and note taking, and would also be useful for making annotations in space provided on book tapes. Acoustic recording (perhaps on an extra channel provided in a multichannel book tape) would permit oral annotation. Further features may emerge as development of the machine proceeds.

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References and Notes

1. The American Printing House for the Blind, in cooperation with IBM, has developed a method of translating Braille by means of standard punch cards for computer input. The Computer Science Laboratory and Honeywell have developed a similar system. The Mechanical Engineering Department of the Massachusetts Institute of Technology is working on computer translation bypassing the step of the punched card. [See also R. W. Mann, "Enhancing the Availability of Braille," *Proc., Int. Congr. Technol. Blindness*, vol. 1 (American Foundation for the Blind, New York, 1963).]
2. I thank E. Groh, T. Pienas, B. Burson, P. Grunwald, L. Wos, B. Spinrad, Mrs. Gretel Grunwald, and Mrs. Julian Levi for their valuable support.

6 June 1966

III. PAPERS ON COMPUTER TRANSLATION, AUXILIARY EQUIPMENT, ETC.

III

THE READING BELT OF THE BRAILLE MACHINE

A crucial component of the Braille Machine is the reading belt; it is the part which produces the output of the whole system and presents it to the user, who interacts with the belt full time during the reading operation. Any shortcoming of the belt will thus degrade overall performance of the machine, and the user will be most directly aware of such shortcomings. A "shortcoming" means here any deviation from the characteristic feel of conventional braille material, especially if a competent user finds it disturbing or objectionable. The belt is furthermore critical for the development of the system, because there exists no technology in other fields that could be applied instead, whereas just about any other component of the Braille Machine is derived from established technology or is available from commercial sources.*

Measured forces (applied centrally and perpendicularly to a bubble on the belt at a low rate) as a function of displacement are known. A more general understanding of behavior of a bubble under less specific or under abnormal (pathological) conditions does not presently exist: the design chosen for the belt embodies flexible materials which are deformed in operation over a range of shape changes which are very large compared to the dimensions of the part involved; this kind of deformation is notorious with respect to difficulties encountered in analysis. As a matter of fact, several consultants hesitated to even suggest models for computer treatment of some of the problems we encountered in producing and operating belts.

It is, of course, not because of perversity that we nevertheless adopted and pursued this difficult and at times frustrating concept. Consider the system specifications with regard to appearance simulating that of regular braille specifies appearance simulating that of regular braille material, fast continuous flow of information, reliability in terms of low error rate, durability over many millions of operations, minimal power consumption, low (system -) weight, low cost, ease of fabrication as well as of maintenance, pleasant feel, and quiet operation; we find it hard to conceive of other candidate ideas and are not aware of any that would not fail the testing against the mentioned criteria in several items.

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*Some of the applicable technology is, however, of very recent vintage, e.g., low power integrated circuits or electronically regulated dc motors.

Where, then, do we stand in the evolution of this essential constituent? To begin with, we are now able to make belts consistently, efficiently, and predictably within close tolerances;* we have demonstrated that no more than scaling-up present fabrication methods is required to bring the (present) cost of one belt of ~ $15 down by another order of magnitude.

The current belt performance can probably best be labelled "acceptable to most subjects." Reactions of users are somewhat dependent on time of practice with the machine, prior braille skill, and other factors (including physique and mentality of the user.) The subjective evaluation ranges from "great!" (after testing all machine speeds with only minutes of exposure to the new experience) to "I do not think I would want to use this" by one more skeptical evaluator. More objectively it can be said that most people who read braille at all competently can read off the belt with little practice (a few hours at most); that typically their reading speed increases and finally significantly exceeds their speed with "ordinary" braille;** that even those--apparently not typical —individuals who read competently with the machine, but feel less "involved" or "affected" by what they read, eventually lose this reaction and read with full satisfaction.

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* The critical pitch dimension, for instance, fairs no more than ± 0.0002 of an inch (~ 1/15 of the thickness of a sheet of paper).

**This does not include those relatively rare individuals whose maximum reading speed already is near or at the apparent upper limit which we found earlier, namely ~ 22 characters per second.

Remaining problems:

(1) Many or most "new" users (but not all) wish the dots were "higher" "stronger," "more distinct," etc. We have run a series of tests to get a clearer understanding what it actually is that bothers these individuals. While it was surprising how well extremely small differences in dot heights can be determined, we found that stiffness of bubbles as a function of slight shape modifications can mask or overwhelm the difference perception in regard to bubble height. It is difficult and time consuming to improve this parameter of "subjective" or "satisfactory bubble height" especially because belt operation is very sensitive to bubble height in a rather complex interrelationship. In the writer's opinion one should "freeze" the current specification for a while, until extensive use with a fixed reference standard has produced a better understanding of how much of the inconvenience is merely due to somewhat unfamiliar feel and may disappear within a reasonably short time (and incidentally almost certainly with acquisition of a habit of reading with a light touch, which is generally desirable).*

(2) A significant number (again not all) of the subjects experienced a numbness or tingling sensation in their finger tips after uninterrupted reading periods of several minutes up to ∿ 1/2 hour. While there appears to be complete recovery after a few minutes of rest, one ought to try to minimize or eliminate this nuisance. This may require considerable study: are we dealing with regular friction, stick-slip friction,

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*The more "objective" data referred to before seem to indicate that the problem might not be as serious as the vocal reaction might suggest.

vibration of the fingers or of the belt, impact on the finger tips by the bubbles, resonant effects in the finger tissues, fatigue, or compounds of such effects?*

(3) While simulated (accelerated) use tests indicate that a belt could run for ∿ 500,000 words and not deteriorate intolerably, and while accelerated wear tests (flexing bubbles mechanically on a stationary belt) point to a figure perhaps yet one order of magnitude higher, few belts have so far lived up fully to the 500,000 word limit and none to the apparent potential; they rather had to be replaced earlier, typically much earlier.** In many cases the "untimely" end was clearly due to accidents, such as children's trying to stop the running belt by bearing down hard or a broken stylus assembly. But the problem is a complex one and therefore difficult to pin down, all the more so because now "accidents" have (as a result of steady, evolutionary improvement of many elements) become quite rare; one may have to observe something like one million stylus operations before one encounters a single malfunction. This makes 100% observation as difficult or impractical as statistical analysis. We have therefore concentrated on scrupulously examining the belts taken out of service, reasoning back from normal operations to conceivable causes of abnormal behavior, and tentatively engineering around inferred causes of malfunctions. The result has been that, similarly to the "readability" of the belt, its

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* It is interesting to note that a very few of our subjects indicated similar experiences with regular (sheet) braille. Could it be that people usually do not read braille without any interruptions for extended periods? The effect may have nothing to do with the medium and rather depend on the mode.

**Because much of the experience with belts were made under conditions of use by different users or operators, different speeds, great variation in the length of each reading period, etc., no good statistics of the average life expectancy exist.

longevity and predictability improved markedly. The "life expectancy of the belt populations" has improved mostly by gradual reduction of "infant mortality" (which is, of course, what one would elect if one had to make a choice, given that the maxima are quite satisfactory, as described). In view of the mentioned discouraging attempts at systematic (computer?) identification of pertinent variables, one looks to continuing the current evolutionary techniques; and one may well hope that this process will accelerate not only as more extensive use provides data at a faster rate, but also as specific causes for failure are eliminated; as the complexity of the set of variables shrinks as one goes along, it may eventually become limited enough to allow more efficient treatment.*

(4) The "closure weld" applied to shape the belt strip into an "endless" loop has been perfected, where it seems amply strong enough and hardly perceptible by the reader; a remaining problem is that sometimes bubbles immediately adjacent to the weld are not reliable, so that the reader feels in some cases a partially "defective" character once in a ∿ 100. Careful "tuning" of the welding process should eliminate this complaint. The most salient feature to the experienced observer is that the stylus alignment of faulted belts is shown to be "early" or "late" and in some cases displaced laterally; in a few cases, there is clear indication of elastic distortion or elongation of the belt at the drive sprocket or

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*On the other hand, as "accident frequency" is further successfully attacked, one has (as indicated) fewer data coming up; but this may eventually be so low a frequency as to make further improvements uninteresting.

- where the belt had "hung up" - over a large part of its length. Conversely all belts which had survived for an exceptionally long use time showed near central imprints. The most important object for further attention is thus the set of factors which affect the "register" between styli and bubbles, foremost among them

(1) careful timing (when belts are changed);

(2) precise control of belt tension;

(3) (if possible) reduction of belt stretchability in prolonged rough use;

(4) close attention to the pitch of the drive;*

(5) close attention to the correct speed of the SIEMENS motor and the electronic "clock" in the stulus timing circuit; and

(6) tight quality control, especially with respect to thickness, surface, and flatness of the belt stock.**

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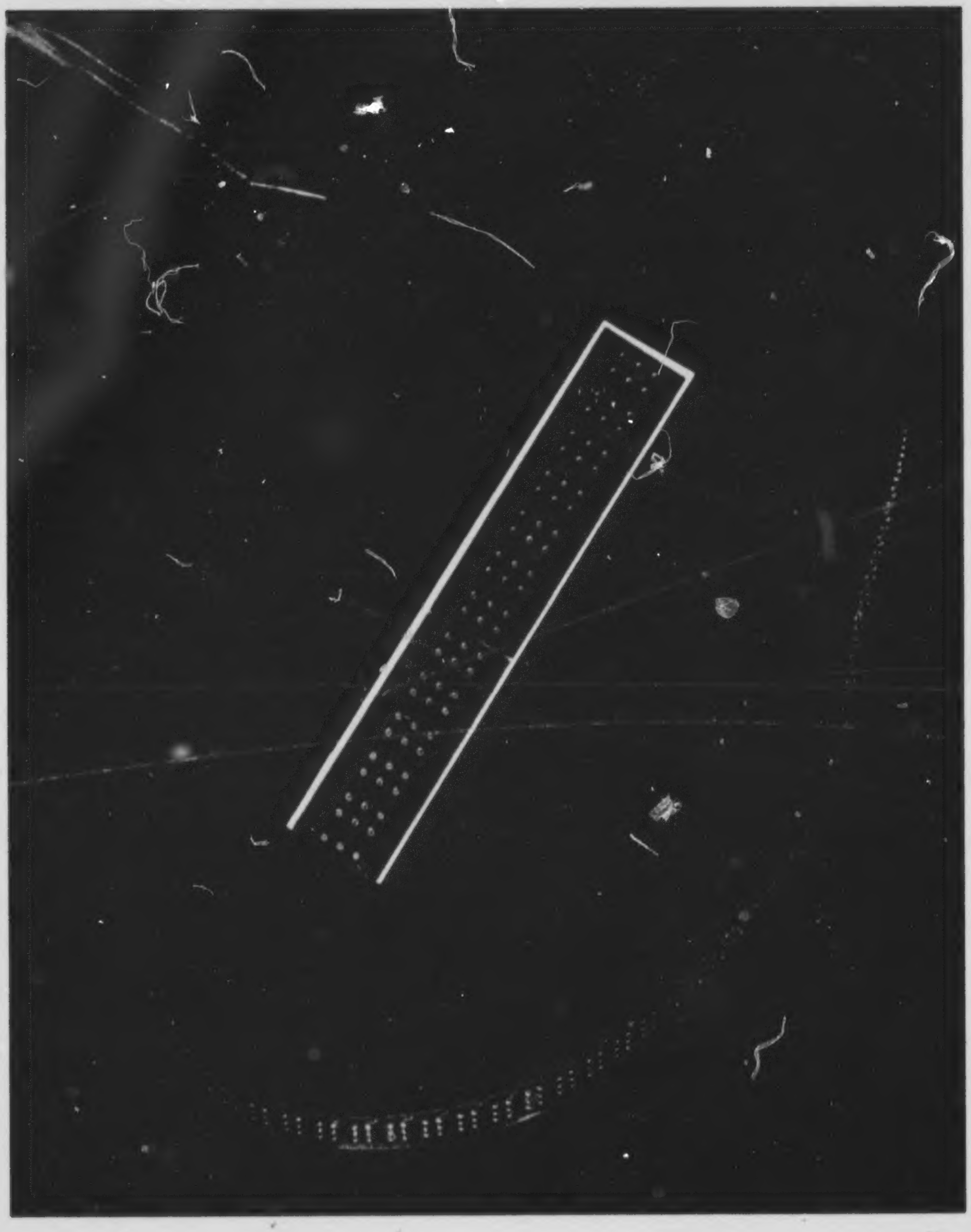
[*] Any deviation in the register of sprocket teeth and belt perforations leads to a shift in the belt transport.

[**] A "fused" instead of the sprayed-on Teflon coat should be developed.



The Reading Belt of the Braille Machine

III-B-1

THE BELTMAKER

The "Beltmaker" consists of:

(1) an air operated press (Danley)

(2) the associated cycling & speed fluidic control (Aro)

(3) a pneumatic strip feeder (Rapidair)*

(4) a vacuum pump with micro 3-way valve (Duo Seal/Aro)

(5) a die set,** comprising 6 styli, heated by circulating, chromate treated, distilled water; a matching hole plate; a stripper; a set of 2 punches and 2 dies; and 2 locating pins (Harig)

(6) a regulated dry air (or nitrogen) supply

(7) a regulated tank - waterheater with pump

(8) a regulated 20 V dc power supply

(9) pressure gauges, filters, oilers, thermometers, thermostat, hoses and piping

(10) entrance and exit chutes for feedstock and belt

(11) stand and cover.

After supplies are connected and primed, only the fluidic control needs to be switched on (twisting the 2 control knobs simultaneously) to operate the apparatus automatically; the knobs lock into operating position and are released to stop the cycling by briefly depressing the large red "panic" button. Speed control and timing valves, pressure regulators, switch and valve actuator settings, the stops governing press stroke and die penetration, stripper pressure, feeder stroke and solenoid voltage need not and should not be touched again once they are properly adjusted. Oil level in the feeder line bowl must be maintained.***

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* Modified by loading the feed clamp with solenoids (in lieu of springs) controlled by a microswitch.

** Designed by ANL.

***Use paraffin base hydraulic oil #10 SAE.

On the downstroke, the sequence of operations is as follows:

(1) a: feeder hold clamp closes b: feed clamp opens c: feeder retracts

(2) solenoids of hold clamp are de-energized

(3) locating pins (2) enter and engage perforations of blank (which were made on previous stroke) to complete (fine -) adjustment of blank location.

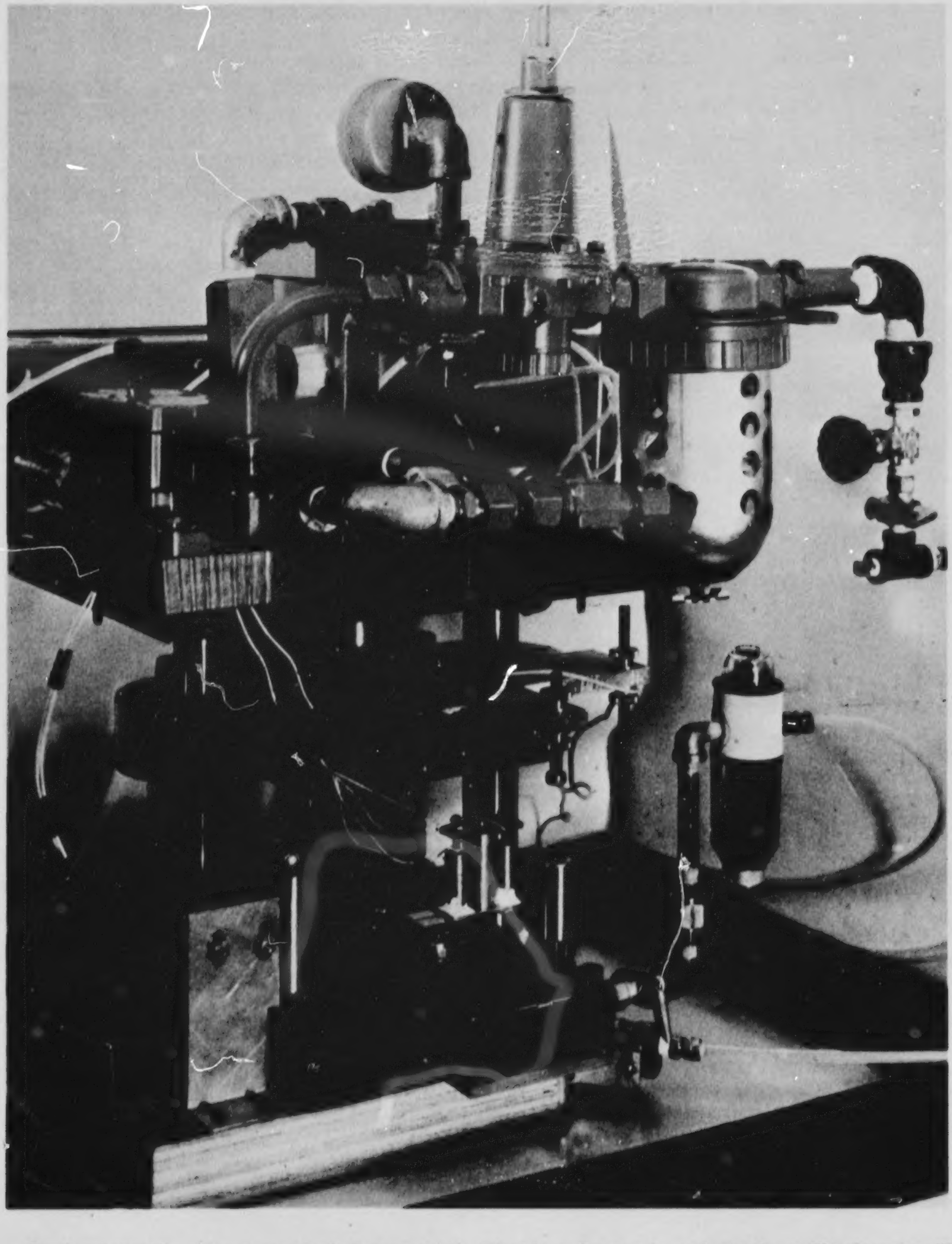
(4) stripper holds blank

(5) vacuum applied under blank

(6) punches (2) engage blank (and dies)

(7) styli (6) engage and extrude blank to form bubbles.

On the upstroke the corresponding opposite actions take place in reverse sequence; the steps (1) take place, however, on the upstroke also as (minus) a→(minus) b→(minus) c in very rapid succession.



Semiautomatic Air-operated Press with Fluidic Control and Feeder ("Beltmaker")

Making Braille Belts - T. Pienias

Stock - 32" wide x 2½ mil thick polypropylene sheet

1. Cut 15/16" wide strips with the grain 32" long.
2. Using scoring fixture, score 2 parallel lines the full length of the 15/16" strips.
3. Fold edges of belt, using score as a guide until edges are approximately perpendicular, forming a channel shape ("pinching" with fingers).
4. Using trim fixture, place full length of preformed strip into fixture against front bar towards belt, and close 4 clamps; belt should now be locked in fixture with flanges of channel shape in upward direction. With a razor blade trim off excess belt material flush with fixture.
5. Using heat forming fixture, place belt full length into slightly opened fixture with flanges in down position. First flange entering fixture must be folded upon itself (similar to a closed hinge) and slipped in. Last flange entering fixture must be assisted with a tool (shim stock 0.010 x 0.25 x 6") with belt in fixture, the fixture is closed when about 0.010" of the folded over edge of belt protrudes from fixture to this edge. Heat is applied with a flameless heat gun (250°F). This sets the folded edge permenantly. The same procedure is followed for the second flange. The resulting belt blank is 0.568" wide with two 0.125" flanges folded over on each side.
6. To each blank is attached, with a scotch tape tab ∿ ½ sq. in., mylar slightly less in width than the blank and about 12" long. Wipe the blank off with acetone to insure cleanliness. Next spray inside (side with flanges on top) with a release agent (MS-122 fluorocarbon); if necessary wipe (loose) excess off (use "kleenex").

7. Insert leader into braille press with sprayed side (side with flanges) on top. Position belt in die to start forming bubbles on belt (not on leader). Check that air, vacuum and electric power is turned on. Also check water temperature (194°F) to assure that die is ready for forming bubbles. Start press and observe feeding mechanism operating properly.

   We should have a belt now approximately 30" long folded over edges with braille characters formed on the center section (single ply) and sprocket holes punched along edges double ply) with a pitch of 0.270" ± 0.0002.

8. Ink mark belt at one end where welding will occur (larger gap between sprocket hole and bubbles). Count off 95 pitches, and ink mark belt again at weld position. Install belt on trim gauge. Guide pins are away from operator as he looks down on trim gauge, and weld mark coincides with edge of gauge (left for one end - right for other end). Trim off excess belt with scalpel.

9. Wash off ends of belt with acetone before welding belts are welded ultrasonically in fixture. Check welder for proper settings.

   (Bronson 400 series ultrasonic plastic welder horn #308-020-020 Welder)

Gap	4.5 mils
Power	31
Weld time	1.0 s
Hold time	0.1 s
Pressure	42 psi

Belt overlaps about 20 mils.

Fixture is an aluminum block with a (raised) welding anvil surface and guide pins for aligning belt.

Load belt into fixture, each end separately. Try belt on guide pins on left side of fixture to see if end coincides with welding surface of fixture, with formed bubbles on belt facing down. Open folded flanges of belt, slip belt over guide pins, and tape open flanges flat down on fixture with scotch tape. Take precaution that belt is not twisted, and follow same procedure with right side of fixture. Right side of belt should overlap left side by a uniform 20 mil. Belt should be flat (single ply) with score marks in line. Hit start buttons and weld. Remove belt from fixture and refold flanges.

10. Wash belt thoroughly with acetone; immerse in ultrasonic tank with surfactant solution for about 5 min.; take out and air dry.

ARGONNE TAPE PRODUCTION FACILITY
SYSTEMS DESCRIPTION

by

R. Foster and W. Lidinsky

ANL T.M. 308, June 1977

1. System Overview

The Braille Tape Production Facility is a system for generating properly formatted 1/4 inch magnetic tapes for the Argonne Braille Machine. It consists of AMP (the Argonne Microprocessor), a Scientific Microsystems Microcontroller, and two Tally incremental 1/4 inch tape drives.

The Braille Tape Production Facility has four modes of operation. They are as follows:

(1) Generate a properly formatted 1/4 inch Braille Machine compatible magnetic tape with braille information from 1/2 inch computer magnetic tape. The 1/2 inch computer tape is generated by the Argonne Braille Translator.

(2) Generate a Braille Machine compatible 1/4 inch "empty" note tape. These tapes will be used by volunteer braillists to transcribe braille material using a Braille Machine and the Portable Braille Input Editor.

(3) Generate a Braille Machine compatible properly formatted 1/4 inch magnetic tape with braille information from 1/4 inch "full" note tape.

(4) Copy 1/4 inch Braille Machine compatible magnetic tapes.

2. System Hardware

A block diagram of the Tape Production Facility is shown in Figure 1. To the left of the dotted line is AMP; to the right is the special equipment dedicated to the Tape Production Facility.

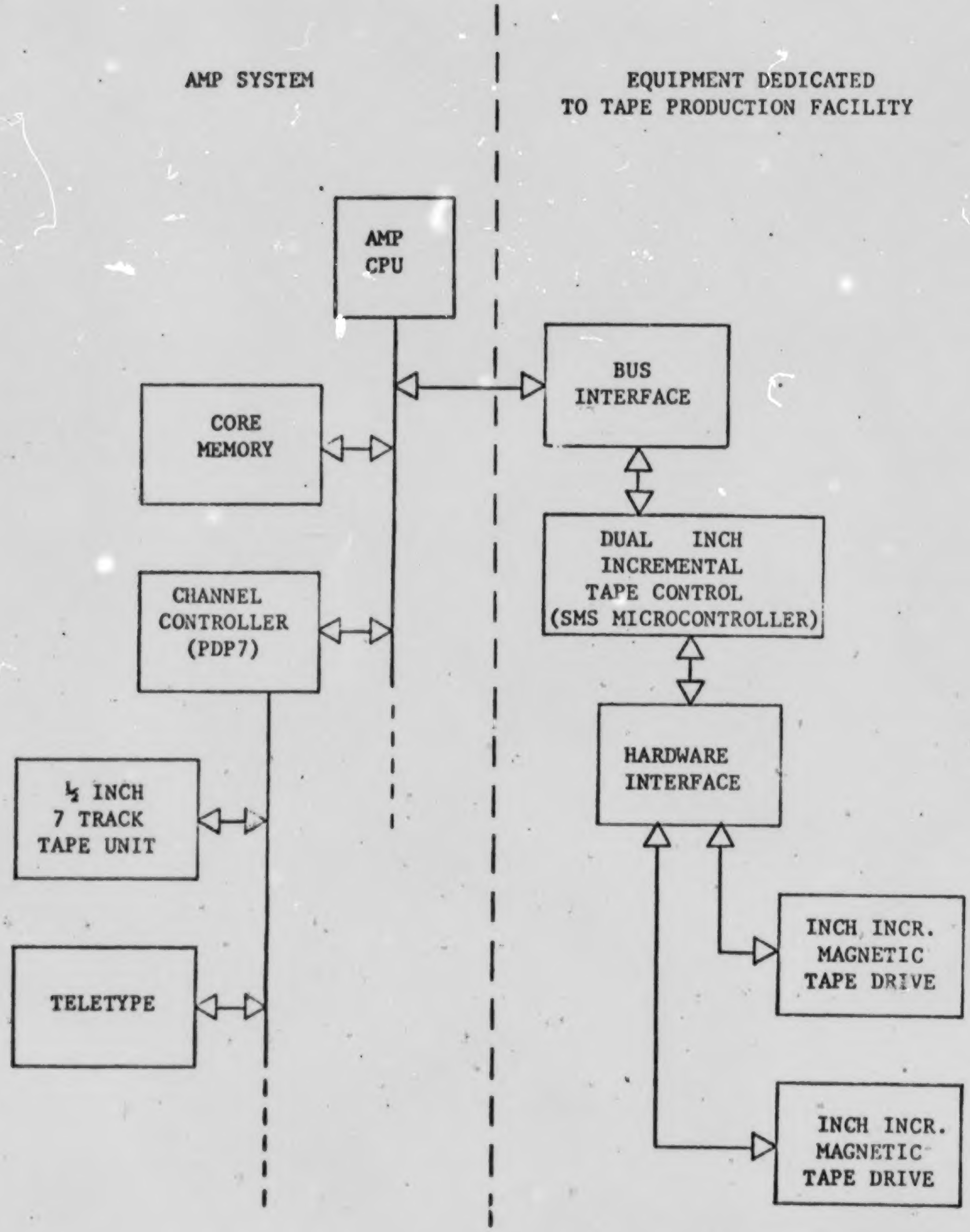

AMP SYSTEM
EQUIPMENT DEDICATED TO TAPE PRODUCTION FACILITY
AMP CPU
BUS INTERFACE
CORE MEMORY
DUAL INCH INCREMENTAL TAPE CONTROL (SMS MICROCONTROLLER)
CHANNEL CONTROLLER (PDP7)
HARDWARE INTERFACE
½ INCH 7 TRACK TAPE UNIT
INCH INCR. MAGNETIC TAPE DRIVE
TELETYPE
INCH INCR. MAGNETIC TAPE DRIVE

FIG. 1: BLOCK DIAGRAM OF ARGONNE TAPE PRODUCTION FACILITY HARDWARE

The incremental control is implemented with a Scientific Microsystems microcontroller which is interfaced to the tape decks and to AMP with minimal hardware. Most of the logic is programmed into the SMS microcontroller. Hardware logic is used only to decode a device address sent out from AMP.

The ¼ inch tape transports contain only the read/write amplifiers and some control circuits for the electro-mechanical devices. The transports have no registers, nor are they capable of doing any logical functions.

The I/O and memory bus of AMP is connected to the SMS Microcontroller with a simple buffer interface. The interface consists of simple decode logic for AMP addresses -3 and -4, and buffer gates for all signal lines from AMP to the Microcontroller.

The I/O for the SMS Microcontroller is handled through IV bytes. These IV bytes are 8 bits wide and may be wired for input only or output only. There are 8 IV bytes in the microcontroller associated with AMP: 2 for address, 2 for data to AMP, 2 for data from AMP, and 2 for AMP bus control lines. There are 3 IV bytes for controlling the 2 tape decks: 1½ IV bytes for each deck.

An I/O request from AMP will set an IOREQ toggle in the interface hardware. This will only be done if the address lines equal -3 or -4, and a pulse comes along on AMP's IOREQ line. Also, AMP sets a R/W line for either reading (0) or writing (1).

AMP is held in a wait state until the microcontroller senses the address decode toggle. If the toggle is set, the microcontroller reads data from AMP or writes data to AMP depending on the status of the R/W line. AMP is released from its wait state when the microcontroller transmits a continue (cont) to AMP.

In this system only AMP may initiate action whether it be a read or write. Two words exist in AMP memory to do this (-3 and -4). AMP can load or store to these addresses in order to initiate a read or write. The microcontroller can only respond to these commands by decoding them in its microcode. The operations that take place will be discussed further in the system software description.

3. System Software

The Tape Production Facility software consists of three separate programs for performing its functions: two reside in AMP, and one resides in the SMS microcontroller. The program in AMP is basically a systems type program that need not be changed or added to, so it will not be described here. The latter two will be described in the following sections.

First, the word format that is used to communicate between AMP and the SMS microcontroller will be described. The word format is divided into two groups: command words (-3) and data words (-4). The command word is shown in Figure 2 and the data word in Figure 3. The command word consists of a 6 bit command code, a 2 bit tape deck unit designator, and a 1 bit channel code.

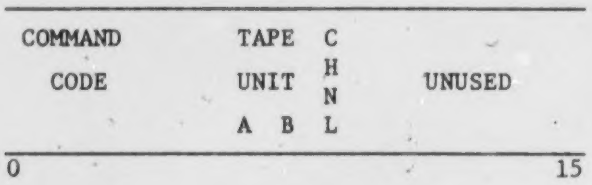


FIG. 2 COMMAND WORD FORMAT

The data word has three possible formats. If the left most bit is a zero, the data word contains either a normal braille character and ID bits in the right byte of the word or an index number and ID bits. The distinction between a braille character and an index number is made by bits 2 and 3 of the left byte. If bits 2 and 3 are zero, zero (00), the word is a normal braille character. If bits 2 and 3 are one, zero (10), the word is an index number.

If the left most bit of the data word is a one, the rest of the word contains control information which generally is a SMS microcontroller status word which contains status of both tape decks.

0	0	0	UNUSED	I D	BRAILLE CHARACTER
0	2	3	7	8	15

NORMAL BRAILLE CHARACTER

0	I D 1 0	INDEX NUMBER (3-4 BIT NUMBERS)
0	2 3	15

INDEX NUMBER

1	CHNL	UNIT A	1	CHNL	UNIT B
0		7	8		15

SMS STATUS WORD

FIG. 3 DATA WORD FORMAT

The software resident in AMP is written in AMPMAC assembly language. AMPMAC is an assembly level language implemented via a microcode interpreter.

The function of the AMP resident software is to provide operator interaction and command word construction for the various functions the Tape Production Facility is designed to perform, and to provide data fitting and buffering between the various peripherals and the SMS Microcontroller. Communication between the system and the operator is via the Teletype printer and keyboard. System messages are sent to the Teletype printer; requested replies are entered on the keyboard.

The command word described previously is constructed from the operator input, and, when all parameters necessary for execution of a function are prsent, the program sends the command word to the SMS Microcontroller.

At certain intervals a command word asking for the status of the SMS microcontroller and the tape decks is sent out. If the reply contains such information as END OF TAPE, the program takes appropriate action.

After a function is complete, the programs go back to their initial status. A message will be sent to the teletype asking for another function.

A block diagram of the AMPMAC program is shown in Figure 4.

The function of the SMS microcontroller microde is to interpret the command word and data words that are transmitted to it from AMP and send control signals added to the Tally tape decks. After program initialization the controller microcode loops, waiting to be addressed by AMP. When AMP addresses the controller, AMP is held in a wait state until the controller releases it.

The first word AMP sends to the microcontroller must be a command word. If it is not, the microcontroller will simply ignore the word just sent. When a command word is received, the microcontroller strips off the command code portion and uses this code as an offset to the proper place in a jump table. This jump table contains jump instructions to the proper code for acting on the command just received. At the proper time within this code a signal is sent back to AMP releasing it from its wait state. The treatment of a data word is handled in much the same way.

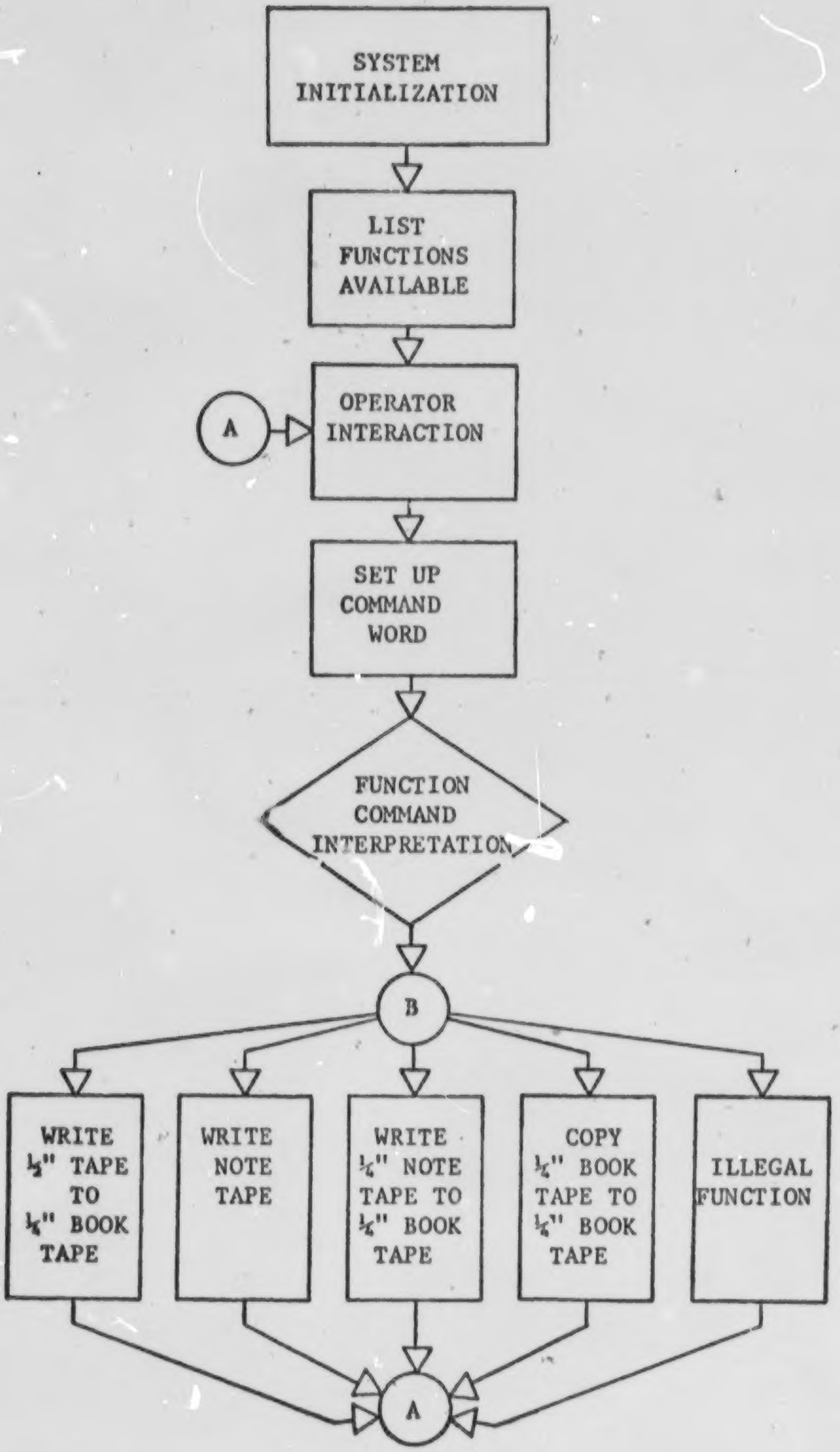

SYSTEM INITIALIZATION
LIST FUNCTIONS AVAILABLE
A
OPERATOR INTERACTION
SET UP COMMAND WORD
FUNCTION COMMAND INTERPRETATION
B
WRITE ½" TAPE TO ¼" BOOK TAPE
WRITE NOTE TAPE
WRITE ¼" NOTE TAPE TO ¼" BOOK TAPE
COPY ¼" BOOK TAPE TO ¼" BOOK TAPE
ILLEGAL FUNCTION
A

FIG. 4: AMPMAC PROGRAM
BLOCK DIAGRAM

Each ¼ inch tape used with the Tape Production Facility has a set of reflective tabs, one at each end. During execution of any command that causes a tape movement, the Microcontroller software periodically checks for one of these tabs. If a tab is encountered, a bit in the tape drive status word is set to a "1". It is up to AMP to issue a command word regularly to check this status word and take appropriate action if one is encountered. A block diagram of the microcontroller software is shown in Figure 5.

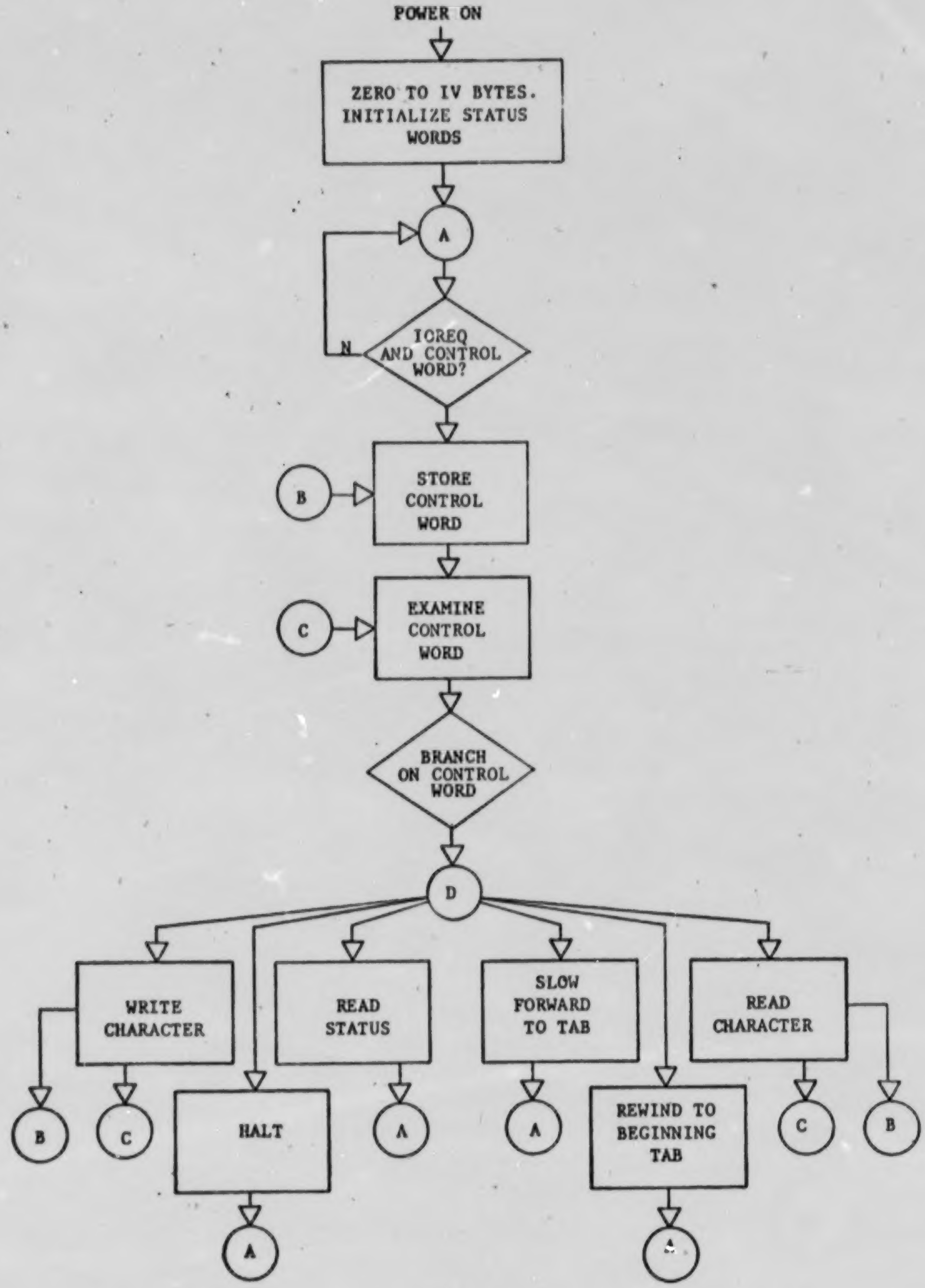
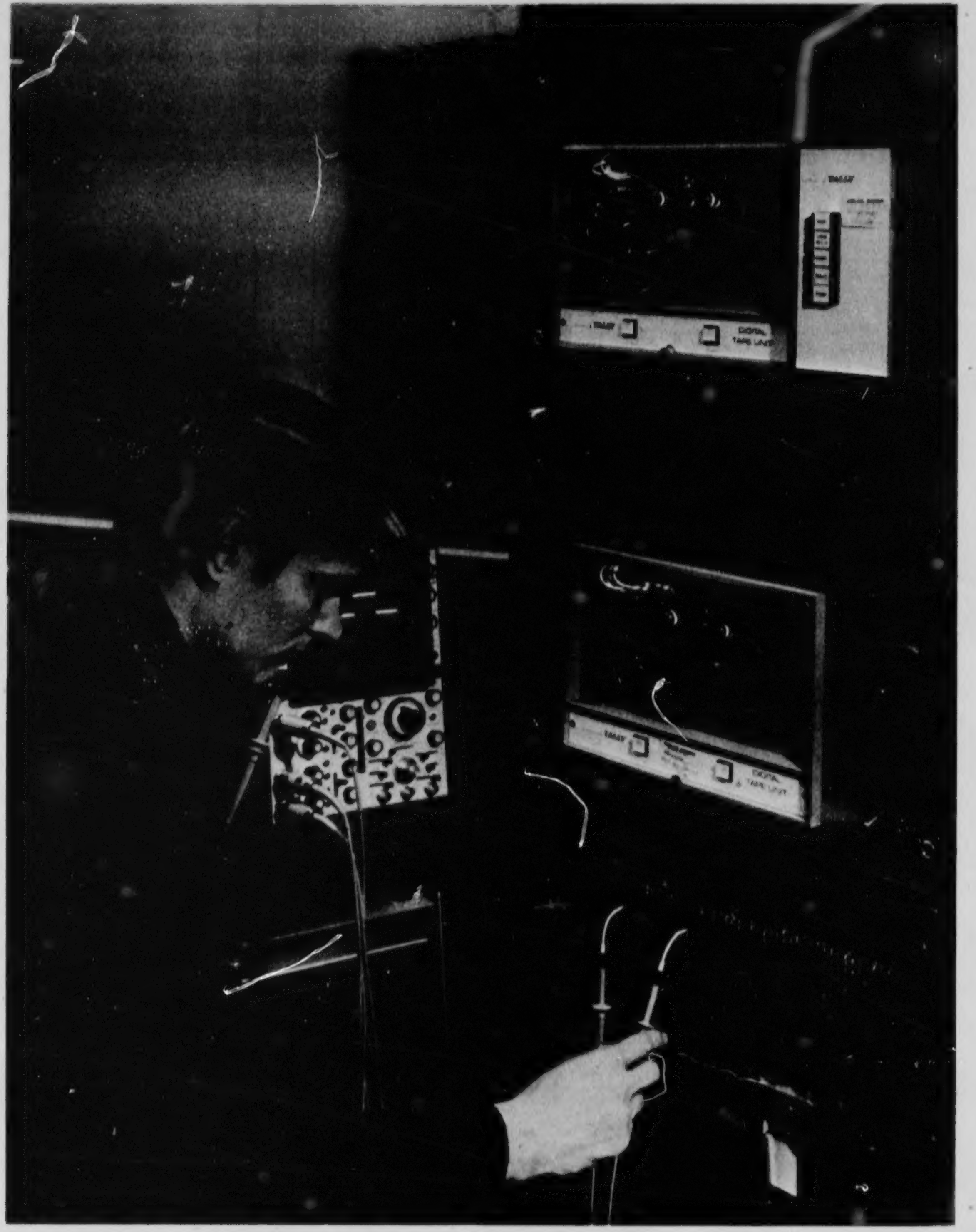

POWER ON
ZERO TO IV BYTES. INITIALIZE STATUS WORDS
A
ICREQ AND CONTROL WORD?
N
B
STORE CONTROL WORD
C
EXAMINE CONTROL WORD
BRANCH ON CONTROL WORD
D
WRITE CHARACTER
HALT
READ STATUS
SLOW FORWARD TO TAB
REWIND TO BEGINNING TAB
READ CHARACTER
B
C
A
A
A
A
C
B

FIGURE 5


DIGITAL TAPE UNIT
DIGITAL TAPE UNIT

Assembly of the Tape Production Facility

ARGONNE BRAILLE MACHINE TAPE PRODUCTION FACILITY

USER GUIDE*

by

Richard Foster

ANL T.M. 307, June 1977

1. Introduction

The Argonne Tape Production Facility was developed by the Applied Mathematics Division as one of the functional systems within the overall Argonne Braille system. As such, it is the sole source of prerecorded quarter inch braille tapes for the Argonne Braille Machine.

The Tape Production Facility interfaces with the Argonne Braille Translator Program for purposes of converting grade two braille translations to the quarter inch tape format. The Facility also interfaces to the Argonne Portable Braille Input Editor for purposes of converting "hand" translated braille into quarter inch tapes. In addition, the Facility is capable of copying quarter inch braille tapes on a quasi production basis and generating properly formatted quarter inch "blank" note tapes. In addition, the Facility can also be used for generating test tapes for machine testing and maintenance.

2. System Overview

The Argonne Braille Tape Production Facility is capable of four major modes of operation. These are enumerated as follows: 1) The Facility can generate properly formatted quarter inch Argonne Braille Machine compatible magnetic tapes with braille information from half inch computer-compatible magnetic tape. The half inch tapes are generated by the Argonne Braille Translator Program. Space for note characters may be interleaved with the text on a fixed ratio basis; the ratio is chosen when the quarter inch tape is generated. 2) The Facility can generate Argonne Braille Machine compatible quarter inch "empty" note tapes. These tapes will be used in conjunction with an Argonne Braille Machine and the Argonne Portable Braille Input Editor. The intent is that they would be used by volunteer braillists to transcribe braille material. 3) The Facility can generate quarter inch "book" tapes from quarter inch "note" tapes. In this mode full note tapes returned by braillists after transcription can be converted to properly formatted quarter inch Argonne Braille Machine compatible tapes. 4) The Facility can copy quarter inch Argonne Braille Machine compatible tapes.

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*For internal distribution only.

The rest of this document discusses and demonstrates, by means of example, the use of the Argonne Tape Production Facility.

3. Operation

Once the Tape Production Facility programs are loaded in their respective computers, the computers may be started; see start up procedures for AMP, PDP-7, and the Micro Controller Simulator. Upon start-up, a list of tape station functions and their responses will be printed on the teletype (see Appendix A). You will note that each function requires a response from the operator. The proper response for the function desired should be entered on the teletype, followed by an EOT (control D) character. If a typing error is made, you will be so informed on the teletype. When a successful entry has been made, the program will ask for more information pertinent to the operation you wish to do. If all information given to the program is correct, the operation specified will be initiated. Upon completion, the system will ask for another function. At this time you may enter another response. The appendix contains several examples of functions and the communications between program and operator.

4. Micro Controller Simulator and Tape Transport Start Up Procedure

1. Make sure the power cord is plugged into a wall outlet.
2. Turn on power strip mounted at the back of the rack.
3. Turn Micro Controller Simulator on. Power switch is located in the lower right hand corner.

   The display panel should read:

   POWER ON. MCSIM SYSTEM START. ACK

   If the above is not displayed, turn unit off. The simulator is not working correctly.
4. Press blue FCN/ACK button. The display panel should now read:

   ```
   TAPE 00000                    LOAD
   ```
5. Load the paper tape marked TAPE STATION, SMS 2/9/77 in the following manner.
   a. Raise the reader cover; the reader is located on the right side of simulator.
   b. Be sure the paper tape width selector on the front of the reader is at 8.
   c. Position the roll of paper tape at the left of the reader. The tape should be positioned so that it unwraps from the top.
   d. Place the tape in the reader so that it slips under the black tab near the rear and so that the sprocket holes are over the reader sprocket teeth. Also, the letter 'S' punched in the tape should be positioned just to the left of the sprocket teeth.
   e. Carefully close the cover. It may be desirable to hold the spool of paper tape with a pencil.

6. Press the FCN/ACK button. The tape should load in. After the tape is loaded the display should read:

```
TAPE 01771                    LOADED
```

The program is now ready to run.

7. Press EXEC button just above the red STOP button. The display should now read:

```
EXEC 00000  617177   HALT
```

8. Press "↑" button located just below the blue FCN/ACK button. The display should now read

```
EXEC 00000   617177   RUN
```

9. Press the FCN/ACK button. The display should now read:

```
EXEC PC=0002n 011L 204R  RUNNING
```

10. If the program should have to be stopped, press the red STOP button.

    a. To restart the program from the point where you stopped, press the "↑" button, then press the FCN/ACK button.

    b. To restart the program from the beginning, press the "↑" button twice. The display should read:

```
EXEC nnnnn  nnnnnn  700000  INSERT
```

If 700000 INSERT is not showing on the display, enter 700000 on the numerical keyboard, then press FCN/ACK. The display should then read:

```
EXEC 00000 617177  700000  INSERT
```

Press the "↓" button, then press FCN/ACK.

5. AMP and PDP-7 Computer Start Up Procedure

1. Be sure proper micro-code is loaded in AMP.

2. Load the PDP-7 computer with the paper tape labeled TAPE STATION 2/1/77.

    a. Raise the EXAMINE switch.

    b. Turn the lever on the paper tape reader to the right.

c. Turn the reader power on.

d. Place the paper tape spool in the tray to the right of the reader.

e. Spool out enough paper tape to reach the tray on the left side of the reader.

f. Slide the paper tape sideways into the reader so you can see it through the round window. Slide the tape all the way to the back so it is flush with the back side of the reader block.

g. Turn the lever to the left.

h. Set octal 330 in the ADDRESS switches located at the right of the PDP-7 console.

i. Press the READ-IN switch. The tape should load and stop at the end of the tape, with an octal 5407 showing in the MEMORY ADDRESS lights and an octal 740040 in the MEMORY BUFFER lights.

j. The PDP-7 program is now loaded.

3. Before starting AMP and the PDP-7 start the Micro Control Simulator.

4. To start AMP:

a. Press MAN switch

b. Press WRITE switch

c. Press UMAR switch

d. Set a Hex 60 in switches on upper part of AMP console.

e. Press LOAD REG switch

f. Press READ switch

g. Press USDR ALL switch

h. Press RUN switch

i. Press RESET; then START on lower part of the console. Run light should come on.

5. To start the PDP-7:

a. Set octal 342 in the ADDRESS switches located at the right of the PDP-7 console.

b. Set octal 1400 in the accumulator switches located at the left of the PDP-7 console.

c. Raise the EXAMINE switch. The MEMORY BUFFER lights should show octal 750004.

d. If AMP is running, press START located at the lower left corner of the PDP-7 console. If AMP is not running, go to the section describing AMP start-up. AMP should always be running before starting the PDP-7.

APPENDIX A

Tape Production Facility
Interaction Scenarios

```
TAPE STATION FUNCTIONS.


WRITE 1/2 IN. TAPE TO 1/4 IN. TAPE.  RESPONSE:  HW

WRITE NOTE TAPE.  RESPONSE:  N

WRITE 1/4 IN. NOTE TAPE TO 1/4 IN. BOOK TAPE.  RESPONSE:  NB

COPY 1/4 IN. BOOK TAPE TO 1/4 IN BOOK TAPE.  RESPONSE:  C


FUNCTION?  >
```

(Program prints this complete list of functions.)

```
FUNCTION?  >HW

1/4 IN. TAPE UNITS?  TYPE A,B,OR,BOTH. >A
BOOK1/BOOK2 OR BOOK1/NOTE?  TYPE BB OR BN >BB
HOW MANY 1/4 IN. TAPES ARE NEEDED? >1
SHALL I CONTINUE? >YES
IS 1/2 IN. TAPE UNIT LOADED? >YES
IS UNIT A READY?  YES OR NO. >YES
```

Execution of function begins here. When complete another function is asked for.

```
FUNCTION?  >HW

1/4 IN. TAPE UNITS?  TYPE A,B,OR,BOTH. >B
BOOK1/BOOK2 OR BOOK1/NOTE?  TYPE BB OR BN >BB
HOW MANY 1/4 IN. TAPES ARE NEEDED? >123
SHALL I CONTINUE? >YES
IS 1/2 IN. TAPE UNIT LOADED? >YES
IS UNIT B READY?  YES OR NO. >YES
```

Execution of function begins here. When a 1/4 in. tape is complete, the last line is printed each time until number of tapes requested is complete.

```
FUNCTION?  >HW

1/4 IN. TAPE UNITS?  TYPE A,B,OR,BOTH. >BOTH
BOOK1/BOOK2 OR BOOK1/NOTE?  TYPE BB OR BN >BB
HOW MANY 1/4 IN. TAPES ARE NEEDED? >999
SHALL I CONTINUE? >YES
IS 1/2 IN. TAPE UNIT LOADED? >YES
ARE BOTH 1/4 IN. TAPE UNITS READY?  YES OR NO. >YES
```

Execution of function begins here. When a 1/4 in. tape is complete, the last line is printed each time until number of tapes requested is complete.

```
FUNCTION?  >HW

1/4 IN. TAPE UNITS?  TYPE A,B,OR,BOTH. >A
BOOK1/BOOK2 OR BOOK1/NOTE?  TYPE BB OR BN >BB
HOW MANY 1/4 IN. TAPES ARE NEEDED? >1
SHALL I CONTINUE? >YES
IS 1/2 IN. TAPE UNIT LOADED? >NO
LOAD 1/2 IN. TAPE UNIT.
IS 1/2 IN. TAPE UNIT LOADED? >YES
IS UNIT A READY?  YES OR NO. >NO
LOAD 1/4 IN. UNIT A.
IS UNIT A READY?  YES OR NO. >YES
```

Execution of function begins here. When complete another function is asked for.

```
FUNCTION?  >HQ

1/4 IN. TAPE UNITS?  TYPE A,B,OR,BOTH. >A
BOOK1/BOOK2 OR BOOK1/NOTE?  TYPE BB OR BN >BN
NOTE EVERY N BOOK CHARACTERS?  TYPE 3 DIGIT NUMBER. >123
HOW MANY 1/4 IN. TAPES ARE NEEDED? >2
SHALL I CONTINUE? >YES
IS 1/2 IN. TAPE UNIT LOADED? >YES
IS UNIT A READY?  YES OR NO. >YES
```

Execution of function begins here. When complete another function is asked for.

```
FUNCTION?  >HQ

1/4 IN. TAPE UNITS?  TYPE A,B,OR,BOTH. >B
BOOK1/BOOK2 OR BOOK1/NOTE?  TYPE BB OR BN >BB
HOW MANY 1/4 IN. TAPES ARE NEEDED? >1
SHALL I CONTINUE? >NO
FUNCTION?  >
```

Operator choose not to execute the function asked for. System requests another function.

```
FUNCTION?  >N

1/4 IN. TAPE UNITS?  TYPE A,B,OR,BOTH. >A
IS UNIT A READY?  YES OR NO. >YES
```

Execution of function begins here. When complete another function is asked for.

```
FUNCTION?  >N

1/4 IN. TAPE UNITS?  TYPE A,B,OR,BOTH. >B
IS UNIT B READY?  YES OR NO. >YES
```

Execution of function begins here. When complete another function is asked for.

```
FUNCTION?  >N

1/4 IN. TAPE UNITS?  TYPE A,B,OR,BOTH. >BOTH
ARE BOTH 1/4 IN. TAPE UNITS READY?  YES OR NO. >YES
```

Execution of function begins here. When complete another function is asked for.

```
FUNCTION?  >N

1/4 IN. TAPE UNITS?  TYPE A,B,OR,BOTH. >A
IS UNIT A READY?  YES OR NO. >NO
LOAD 1/4 IN. UNIT A.
IS UNIT A READY?  YES OR NO. >YES
```

Execution of function begins here. When complete another function is asked for.

```
FUNCTION?  >NB
MASTER TAPE ON 1/4 IN. UNIT?  A OR B. >A
SLAVE TAPE ON 1/4 IN. UNIT?  A OR B. >B
ARE BOTH 1/4 IN. TAPE UNITS READY?  YES OR NO. >YES
```

Execution of function begins here. When complete another function is asked for.

```
FUNCTION?  >NB
MASTER TAPE ON 1/4 IN. UNIT?  A OR B. >B
SLAVE TAPE ON 1/4 IN. UNIT?  A OR B. >A
ARE BOTH 1/4 IN. TAPE UNITS READY?  YES OR NO. >YES
```

Execution of function begins here. When complete another function is asked for.

```
FUNCTION?  >NB
MASTER TAPE ON 1/4 IN. UNIT?  A OR B. >A
SLAVE TAPE ON 1/4 IN. UNIT?  A OR B. >A
INPUT ERROR.  RE-ENTER.

MASTER TAPE ON 1/4 IN. UNIT?  A OR B. >A
SLAVE TAPE ON 1/4 IN. UNIT?  A OR B. >B
ARE BOTH 1/4 IN. TAPE UNITS READY?  YES OR NO. >YES
```

Execution of function begins here. When complete another function is asked for.

```
FUNCTION?  >C
MASTER TAPE ON 1/4 IN. UNIT?  A OR B. >A
SLAVE TAPE ON 1/4 IN. UNIT?  A OR B. >B
ARE BOTH 1/4 IN. TAPE UNITS READY?  YES OR NO. >YES
```

Execution of function begins here. When complete another function is asked for.

```
FUNCTION?  >C
MASTER TAPE ON 1/4 IN. UNIT?  A OR B. >B
SLAVE TAPE ON 1/4 IN. UNIT?  A OR B. >A
ARE BOTH 1/4 IN. TAPE UNITS READY?  YES OR NO. >YES
```

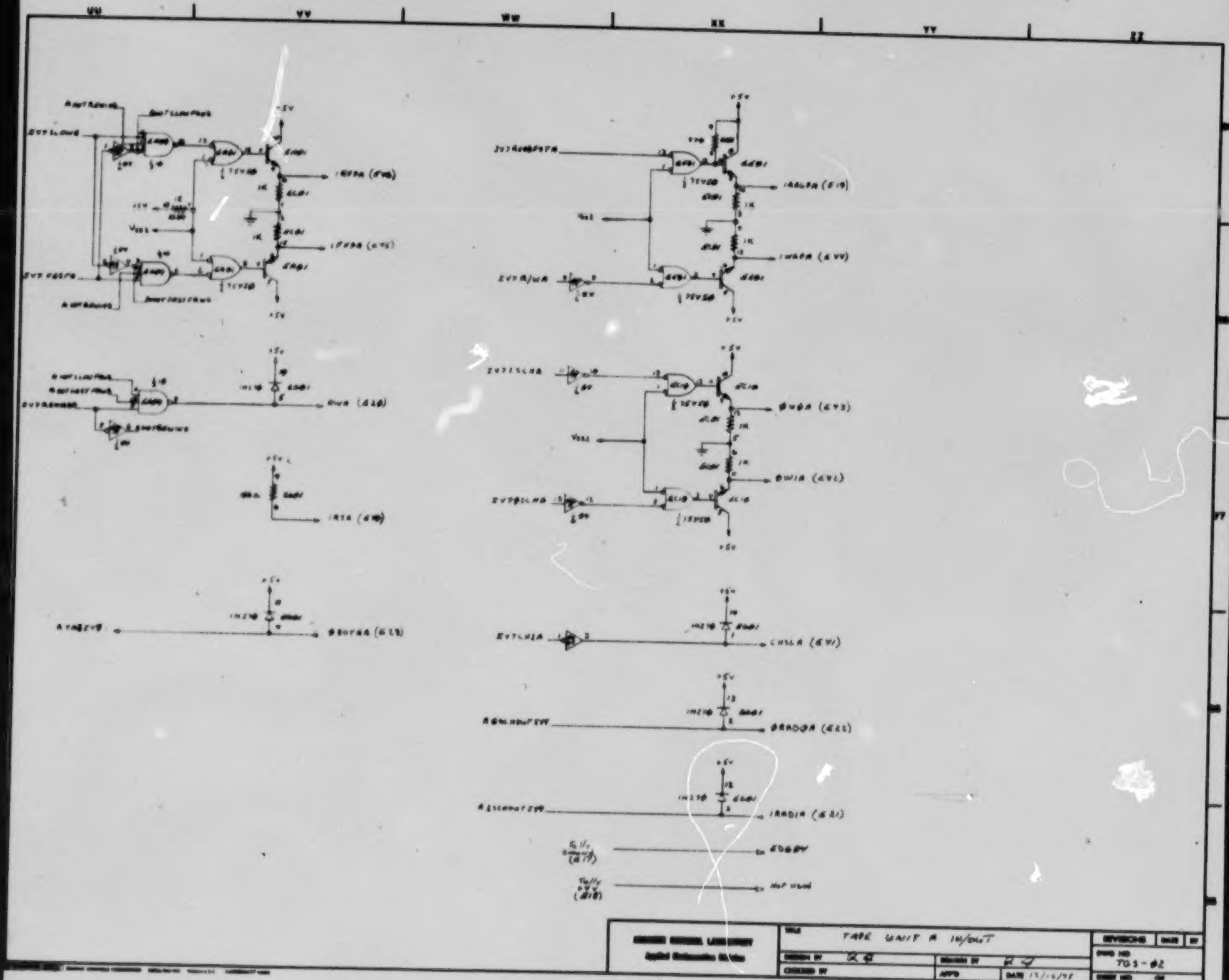
Execution of function begins here. When complete another function is asked for.

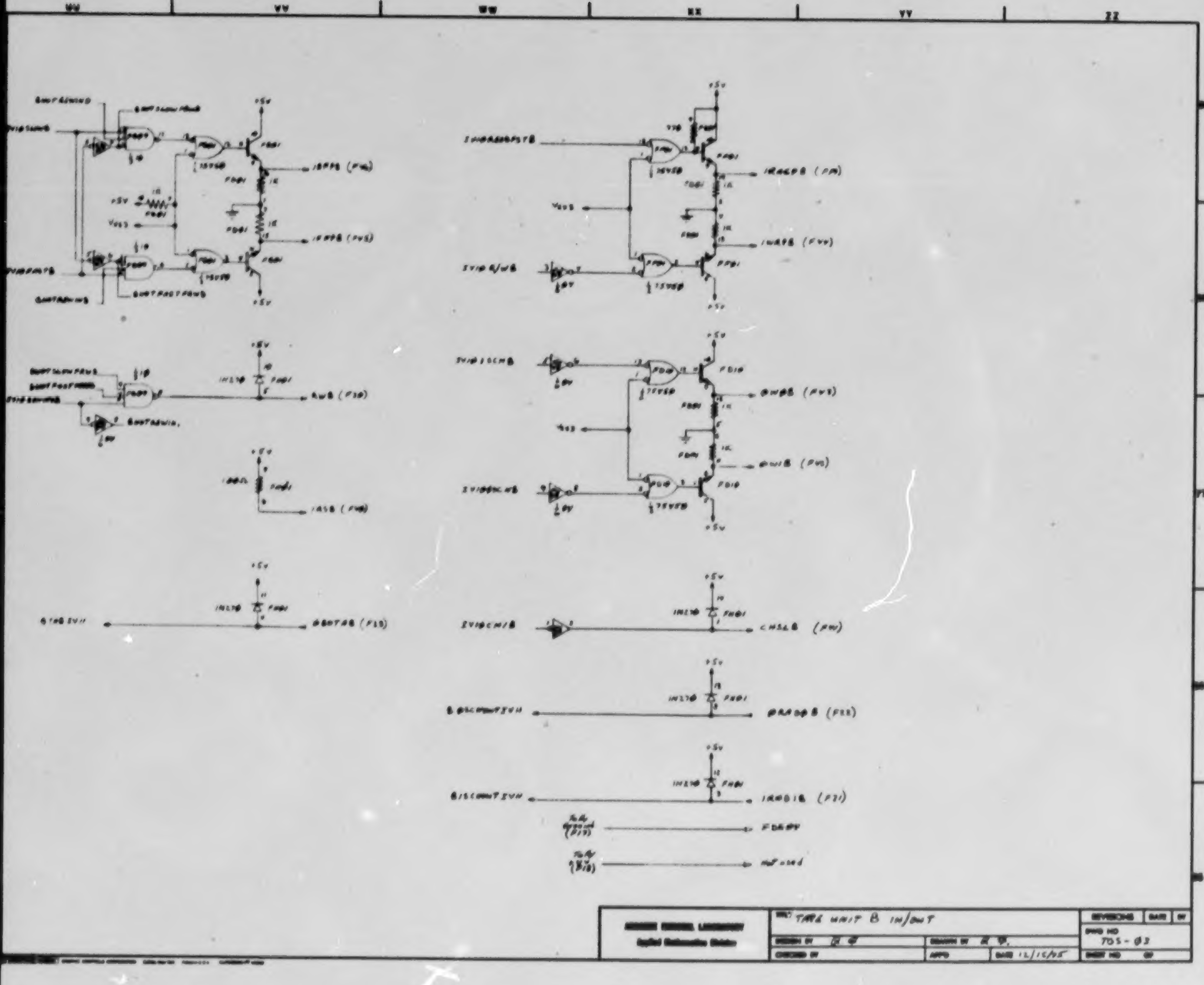
```
FUNCTION?  >C
MASTER TAPE ON 1/4 IN. UNIT?  A OR B. >A
SLAVE TAPE ON 1/4 IN. UNIT?  A OR B. >A
INPUT ERROR.  RE-ENTER.

MASTER TAPE ON 1/4 IN. UNIT?  A OR B. >A
SLAVE TAPE ON 1/4 IN. UNIT?  A OR B. >B
ARE BOTH 1/4 IN. TAPE UNITS READY?  YES OR NO. >YES
```

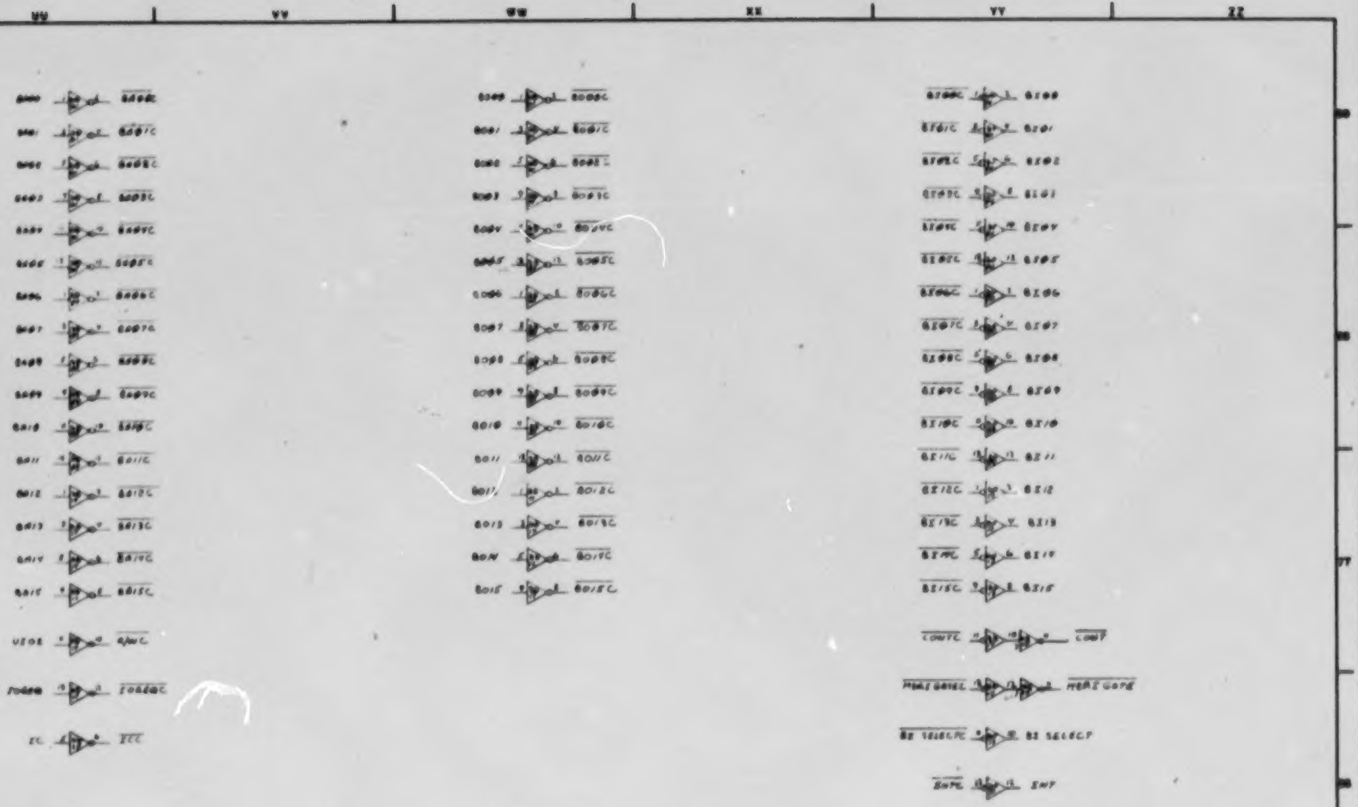
Execution of function begins here. When complete another function is asked for.

```
FUNCTION?  >QH
INPUT ERROR.  RE-ENTER.

FUNCTION?  >HQ

1/4 IN. TAPE UNITS?  TYPE A,B,OR,BOTH. >C
INPUT ERROR.  RE-ENTER.


1/4 IN. TAPE UNITS?  TYPE A,B,OR,BOTH. >A
BOOK1/BOOK2 OR BOOK1/NOTE?  TYPE BB OR BN >NB
INPUT ERROR.  RE-ENTER.

BOOK1/BOOK2 OR BOOK1/NOTE?  TYPE BB OR BN >BN
NOTE EVERY N BOOK CHARACTERS?  TYPE 3 DIGIT NUMBER. >1234
INPUT ERROR.  RE-ENTER.

NOTE EVERY N BOOK CHARACTERS?  TYPE 3 DIGIT NUMBER. >5
HOW MANY 1/4 IN. TAPES ARE NEEDED? >1234
INPUT ERROR.  RE-ENTER.

HOW MANY 1/4 IN. TAPES ARE NEEDED? >999
SHALL I CONTINUE? >YES
IS 1/2 IN. TAPE UNIT LOADED? >YEP
INPUT ERROR.  RE-ENTER.

IS 1/2 IN. TAPE UNIT LOADED? >NOP
LOAD 1/2 IN. TAPE UNIT.
IS 1/2 IN. TAPE UNIT LOADED? >YES
IS UNIT A READY?  YES OR NO. >NO
LOAD 1/4 IN. UNIT A.
IS UNIT A READY?  YES OR NO. >YES
```

Execution of function begins here. When complete another function is asked for.


UU
VV
WW
XX
YY
ZZ
+5V
1K
Not used
TAPE UNIT A IN/OUT
TGS - 02


UU
VV
WW
XX
YY
ZZ
+5V
IN270
not used
TAPE UNIT B IN/OUT
REVISIONS
DATE
BY
DWG NO
705-03
SHEET NO
DESIGN BY
DRAWN BY
CHECKED BY
APPD
DATE 12/15/75

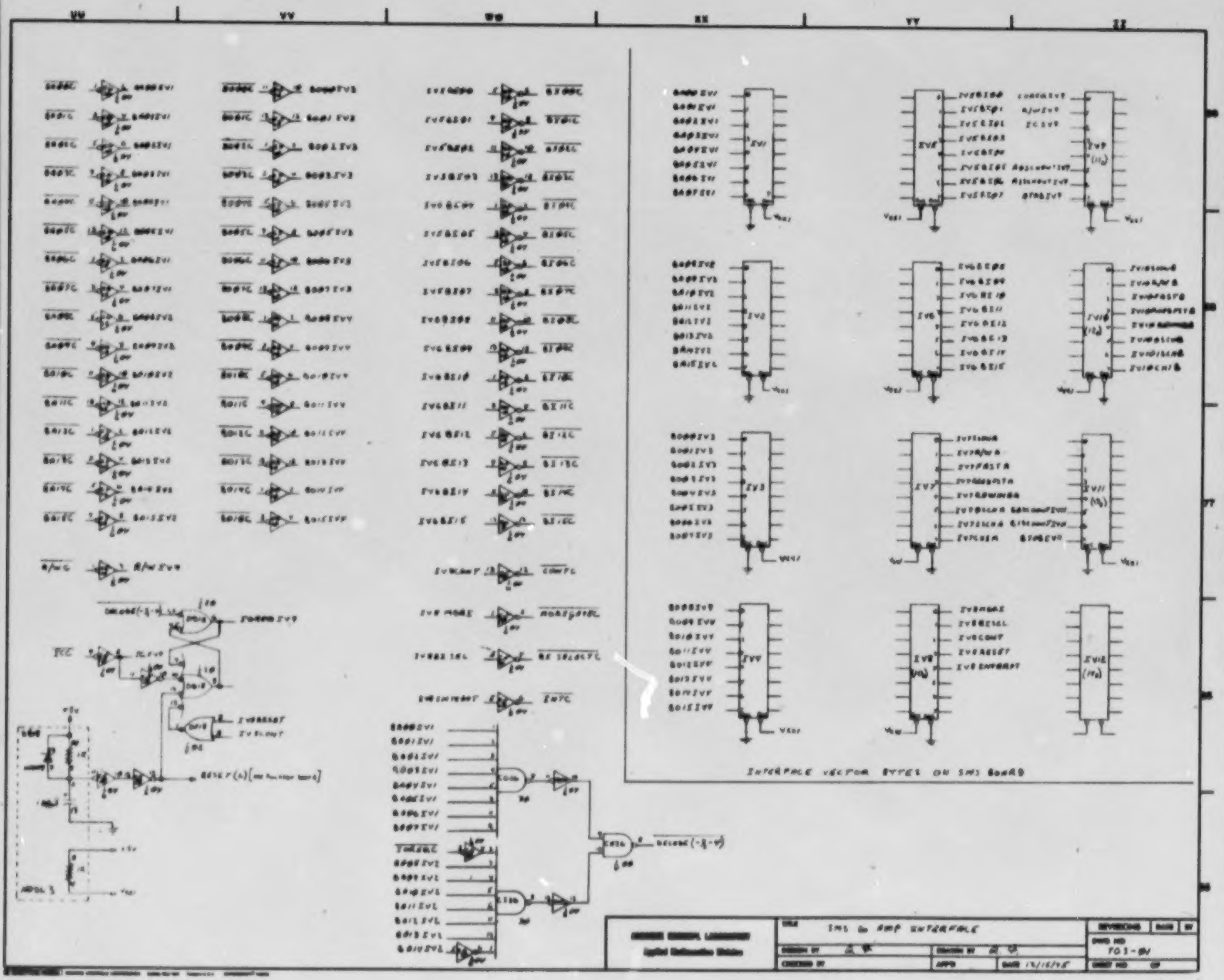


UU
VV
WW
XX
YY
ZZ
COUT
MERZ GATE
BZ SELECT

NOTE:
All IC's are 7404

BRAILLE TAPE STATION INTERFACE
AMP BOARD A&B

DRAWN BY R. F.
DATE 7/23/75


INTERFACE VECTOR BYTES ON SMS BOARD
SMS to AMP INTERFACE
DATE 12/16/75
701-SV

ARGONNE PORTABLE BRAILLE INPUT EDITOR

by

B. Kroupa, W. P. Lidinsky, and A. Grunwald

ANL T.M. 309, June 1977

1. Introduction

This report provides a description and working prints for the Argonne Portable Braille Input Editor. The Editor consists of a Perkins Brailler and an electronic module built into the Brailler's base. The Editor works like a normal Brailler as far as the user is concerned. In addition, the electronic module stores braille characters as they are typed. This information is subsequently transmitted to an Argonne Braille Machine, a line at a time, for storage on 1/4 inch magnetic tape. Editing features are provided so that lines may be changed prior to sending them to the Braille Machine.

2. General Description

Normal operating techniques were chosen for implementing the Editor. As far as the user is concerned, the primary difference between operating a Perkins Brailler and a Braille Input Editor is that the operator must wait after the platen is advanced by one line with the line feed to type. Furthermore, a slight difference exists in the way an error is corrected.

Referring to Fig. 1, light coupled switches (TIL138's) are incorporated in such a way that depressing any combination of dot keys activates corresponding switches and stores their contents through a Buffer Register into an INTEL 8101 Solid State Memory. At the same time the switch data are stored in memory, the next unused memory address is stored in a memory address register (a 74L193 up down counter). This process continues until up to a full line (40 characters or less) of text is terminated by an operator-initiated line feed. The line feed starts the output mode. First the complement of the memory address register is gated to the memory transfer register. The memory address register is then cleared to zero, and the contents of memory address zero are put out to the Braille Machine. After that character is complete, the memory address register is incremented, and the memory transfer register is decremented. This process continues until the contents of the memory transfer register become one. This condition signals the electronics that the transfer is complete and new data can be entered. To make the user aware of the transferring process taking place, an audible alarm is sounded until all transferring is done.

Two exceptions to normal Perkins Brailler operation exist. When an error, in the text has been detected by the user reading a line of text prior to depressing the line feed key, proper procedure is to backspace to the error, counting the number of back steps, make the correction, and then hold down the "space-over" switch located on the front cover of the brailler while activating the space bar the same number of times that the back space key was depressed. This feature allows the correction of characters and memory entries and the return to the location which existed prior to the detection of the error.

The second exception is that, with experience on this device, up to 127 characters or approximately 3 lines of text may be transferred to the Braille Machine at one time. This is accomplished by rotating the carriage by hand for lines one and two and then depressing the line feed key after line three.

Figures 2, 3, 4, and 5 show pictorial views of various assemblies within the Editor.

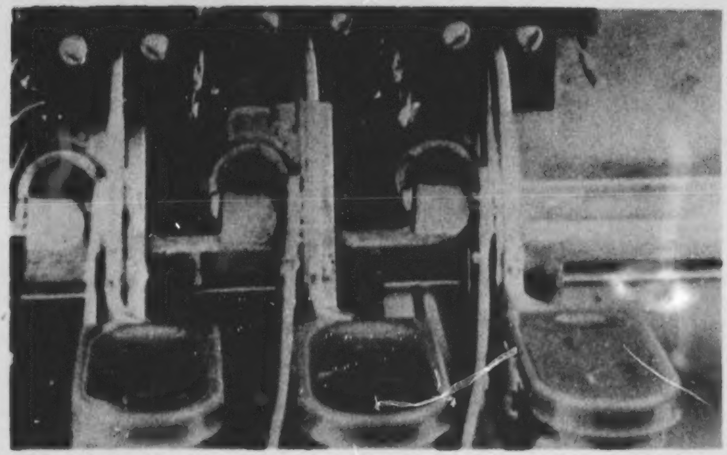


Fig. 2 Close-up of Photo Coupled Switch

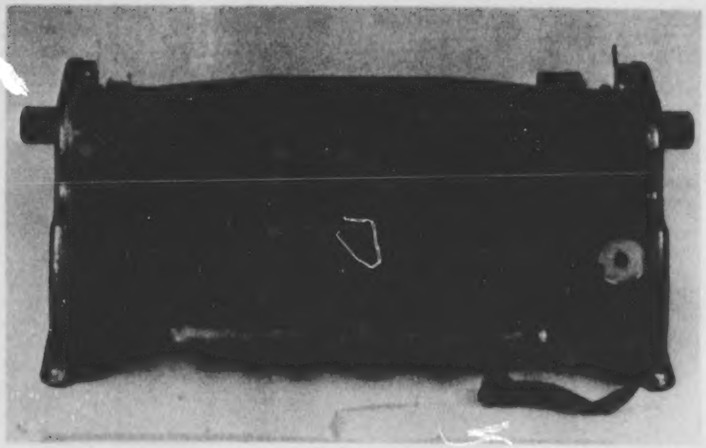


Fig. 3 Overall View of Mounted Switches

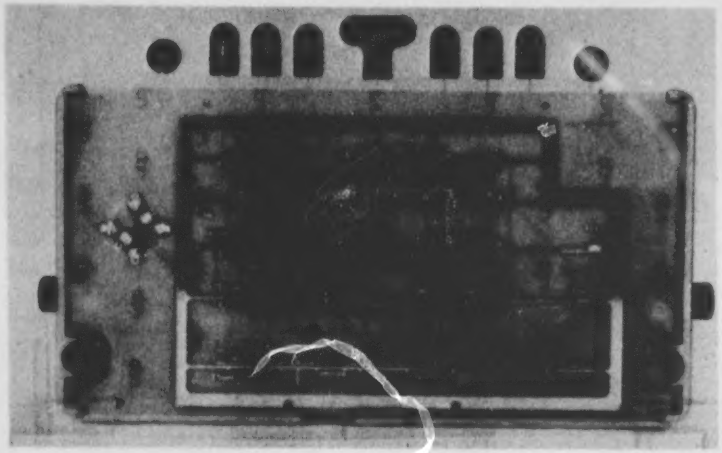


Fig. 4 Back side of Brailler CKT Board Mounted on Perkins Brailler

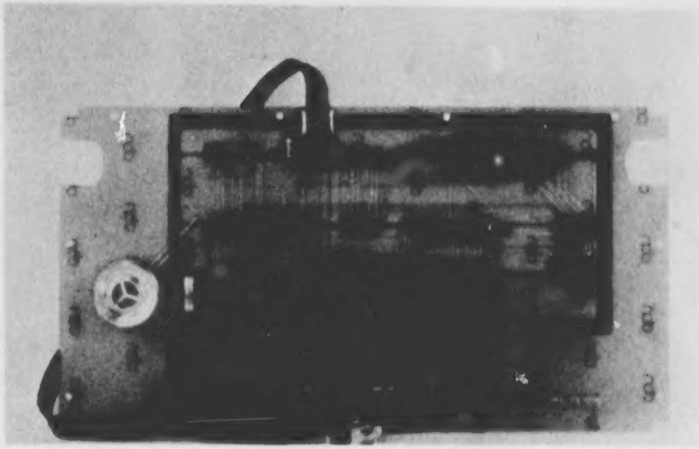


Fig. 5 Component Side of Brailler CKT Board

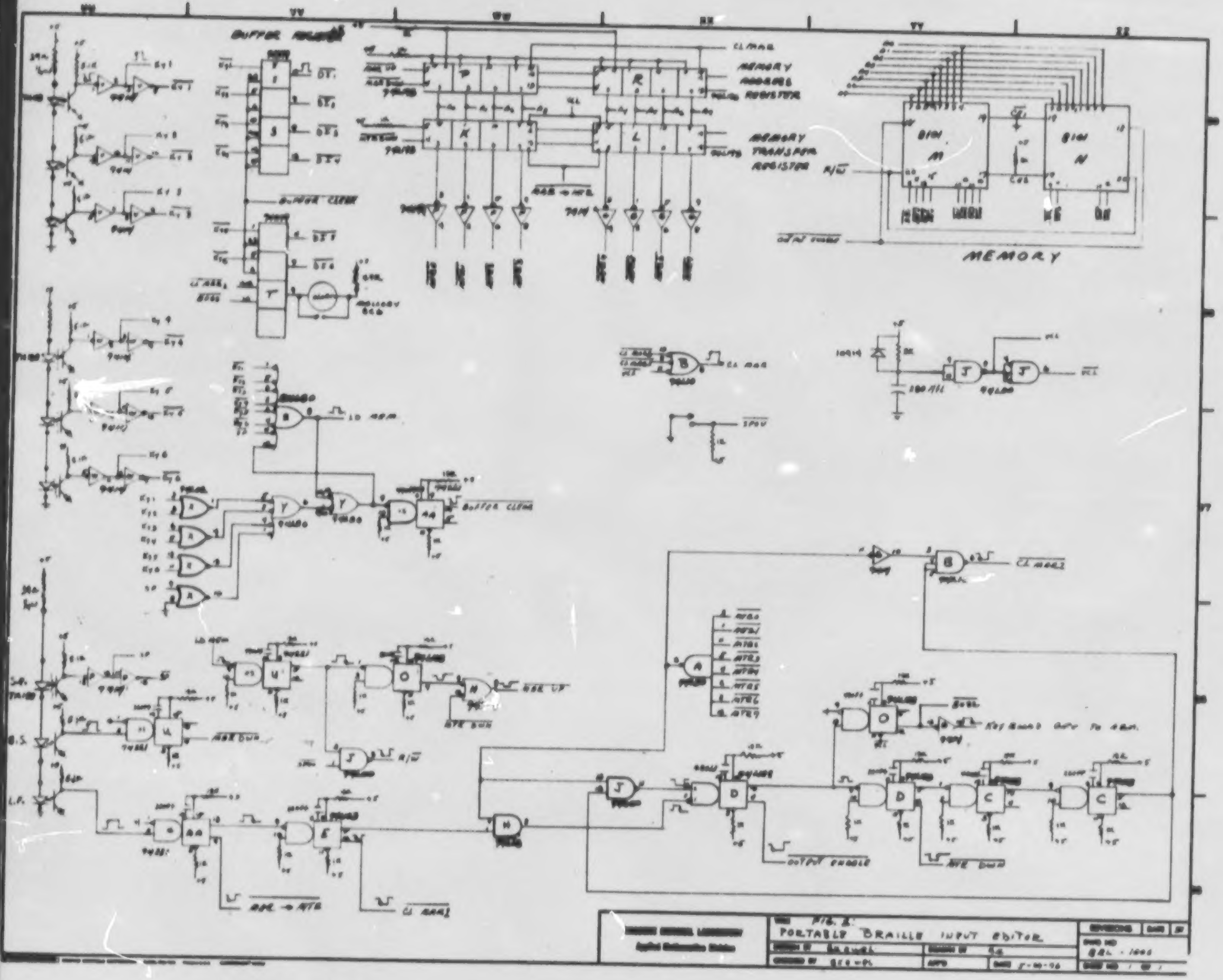

BUFFER REGISTER
MEMORY
ADDRESS
REGISTER
MEMORY
TRANSFER
REGISTER
R/W
MEMORY
8101
M
N
BUFFER CLEAR
LD MEM
CL MAR
CL MAR1
CL MAR2
ADR UP
ADR DWN
MTR DWN
OUTPUT ENABLE
KEYBOARD OUTPUT TO MEM.
MAR → MTR
S.P.
B.S.
L.F.

FIG. 2
PORTABLE BRAILLE INPUT EDITOR

BRL - 1000

5-10-76

AN ON-LINE SYSTEM FOR IMMEDIATE BRAILLE PRESENTATION OF COMPUTER-STORED INFORMATION TO THE BLIND*

by

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The ever-increasing use of automated data processing facilities at all levels of business operation makes it necessary for an individual who wants to operate in these areas to be capable of bi-directional communication with such data systems. This presents particular problems to the blind: while they are quite capable of uni-directional communication with existing data systems through keyboards and other standard input devices, the blind can, at present, receive output only in cumbersome and frequently ineffective ways. Effectiveness of the blind in these environments is hampered by the inability to accept standard output such as teletypewriter output, printed listings, and character displays.

In the last several years, a number of attempts have been made to facilitate output for the blind. These attempts have taken the form of braille computer listings, embossed tape, devices to read standard print, etc. Each of these methods provides some capability for the blind. However, each has drawbacks, and none exhibits the speed and selectivity required by an efficient data system user. Their availability is generally limited by the requirement that an employer provide modifications of his system to accommodate blind users and, furthermore, where speed is essential, the blind person's limited ability to scan or skim over a mass of data is not helped in the output approaches mentioned.

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*1972 Carnahan Conference on Electric Prosthetics, Lexington, Kentucky, September 21-23, 1972.

One of the devices which are employed in computer-based data systems at a rapidly increasing rate is the video terminal. This device communicates bi-directionally with a computer system by direct connection or via telephone lines. Input facility is provided generally by a standard keyboard plus various control keys. Output is provided by a cathode ray tube which displays alphanumeric information. This device permits the user rapidly and selectively to inspect large quantities of data as well as modify, delete or add to the computer files. Many corresponding jobs require no uncommon or highly developed skills, and the bulk of computer related jobs in the business sector are in this category; that is, they can be mastered relatively easily if one can use a video terminal. Thus, to open up employment opportunities for the blind, it would be highly desirable to provide employers with a device which can be easily substituted for a video terminal and, at the same time, has an output mode suited for a blind operator.

To date, no one has solved the problem to provide such a terminal environment. More specifically, no one has offered to the blind a braille substitute for the cathode ray tube. In the general case, at first inspection, the problem appears merely to be one of substitution. If, for instance, the display had 20 rows of 72 characters each, the requirement is to merely provide 20 rows of 72 character braille transducers. At closer inspection, this direct substitution appears neither desirable nor technically feasible.

First, at normal braille cell spacing (approximately 1/4 inch) each line would be eighteen inches long, without any provision for escape characters. With the required escape characters, the lines could easily be 20" long giving a minimum 20" x 8" area. One doubts the utilization of such an area for long periods without excessive arm fatigue. Secondly, the provision of such a braille array at normal cell spacing utilizing solenoids or similar electromechanical devices is at best a nightmare. Similar problems exist to some degree with a parallel (printer type) embosser. Third, and most importantly, one must consider the difference in information assimilation technique between the sighted and the blind. For the blind, the normal sighted eye-scan cannot be duplicated. Information must be assimilated almost strictly serially because of the characteristics of tactual sensors. This means that the presence of, say, an entire page of information ceases to be an advantage. Therefore, textual information presented to the blind must be augumented by nontextual information in the form of grouping and indexing so that the tactile equivalent of the sighted scan may be performed. Fortunately, the information required in the performance of moderately skilled jobs (e.g., order taking, information service, etc.) typically resides already in the machine in correspondingly organized form; the twofold problem is, therefore, essentially reduced to the single one of providing a suitable output and control set.

The most promising approach appears to be a serial output device, with appropriately high speed capability and with sufficient control to permit the operator wide latitude in the selection of information. A device which appears to have these characteristics is the Argonne Braille Machine display mechanism.

Obviously, there are only a limited number of modes or ways of how one can display braille. One such mode may be called stationary, another one dynamic. A stationary display would be one (like a page of braille on a table) which is there for the reader to do something with. On the other hand, a dynamic display would be, for instance, a set of characters moving under the reader's fingertips while the person just watches what is going on. There are other basic modes one can think of; let's take a line as an element. It can be displayed in full length, and after it has been read, it is removed and the next one appears, or you could move normal to the reading surface to present and remove characters formed, for instance, by rising and falling pins. Conversely you could have,as the principal mode of a dynamic display, a line which is really endless and just moves from right to left through a window, so that the sensation if you hold your fingers to the window is essentially the same as if you sweep the line on a stationary display with your fingers.

We do not propose to go into all the combinations and permutations here. But we did try to explore possible modes somewhat systematically; for this purpose, we built a device which allows to move a sheet of paper with embossed characters in different modes stepwise up, continually up, sideways stepping and continually, in various increments and with adjustable speed. The only mode that people couldn't read at all was several lines available at a time and kept in a steady upward motion so that one has a relatively large set of characters at any one time accessible. But, as mentioned, this mode does not work; the sweep by the user's hand from left to right and the movement of the characters set from the bottom up left the user with no fixed reference, and he kept losing his place. Conversely, tests with a line moving constantly from right to left with adjustable speed seemed, from the standpoint of the reader, the most favorable ones, and it turned out from an engineering standpoint also preferable to anything else; maybe it's just because we know how to do it or that we found out how to do it, but we think there is a systematic advantage in this mode.

We then designed a machine which contains a plastic belt which runs over a platen and recirculates around two pulleys. There are some mechanisms which do the writing and erasing of characters on this belt; a reader puts his fingers on the belt on the platen - and here we go! A sensitive trigger under the platen starts the transport, a selector switch provides different modes of operation, and finally there is a speed control for the operator to use. One can, of course, if one misses a character, move on with the belt a little, to spend a bit more time with each character; then, later on, one has to make that up by shifting one's hand gradually back upstream. In short, there is some buffering available in a dynamic display. The average rate is, however, adjusted to suit conditions by means of the speed control.

With such an output device, the problem becomes one of optimizing the man-machine interaction (cybernetics). In this matter, one needs to consider learning mechanisms of the blind. For example, blind people achieve quite satisfactory mobility, particularly in familiar surroundings. Contrary to some seeing people's ideas, they do not need for this to commit to memory, for instance, the number of paces between objects, but they appear to develop from a multiplicity of clues a subconscious awareness of topography. It is this type of ability which must be counted on for the terminal design. A number of interesting questions arise such as:

1. How general in nature or specific to a particular application (job function) should the terminal be?
2. What design features would mimimize job training requirements?
3. What should be the physical placement of the output device relative to the keyboard to facilitate the input-output dialogue?
4. What "start", "stop" and/or "speed" control (knee, foot, etc.) should be provided for optimum utilization?
5. Should an audio indicator be provided to announce the arrival of information from the computer?
6. Are normal video terminal cursor selection controls (LEFT-RIGHT-UP-DOWN-CARRIAGE RETURN-HOME*, etc.) sufficient for braille information selectivity (e.g., column scan)?

Answers to these and other questions must be studied. It is anticipated that this can be done without great difficulty.

A necessary objective in providing a device of the kind discussed for the blind is that it requires no modification to the host system beyond that normally required for the variety of video terminals being marketed. This requirement does not appear to present a major restriction for several reasons. First, memory is ordinarily provided at the terminal from which the video display is refreshed. The same (type of) memory will provide the braille output as requested by the operator. This means that additional logic will be provided in the braille terminal for alphanumeric to braille character conversion, as well as escape character generation (not a formidable task in Braille I). Second, both the memory and the keyboard will appear electrically identical to a standard terminal unit.

A terminal of the type described has applications in many areas where computer-based data systems are currently in use.

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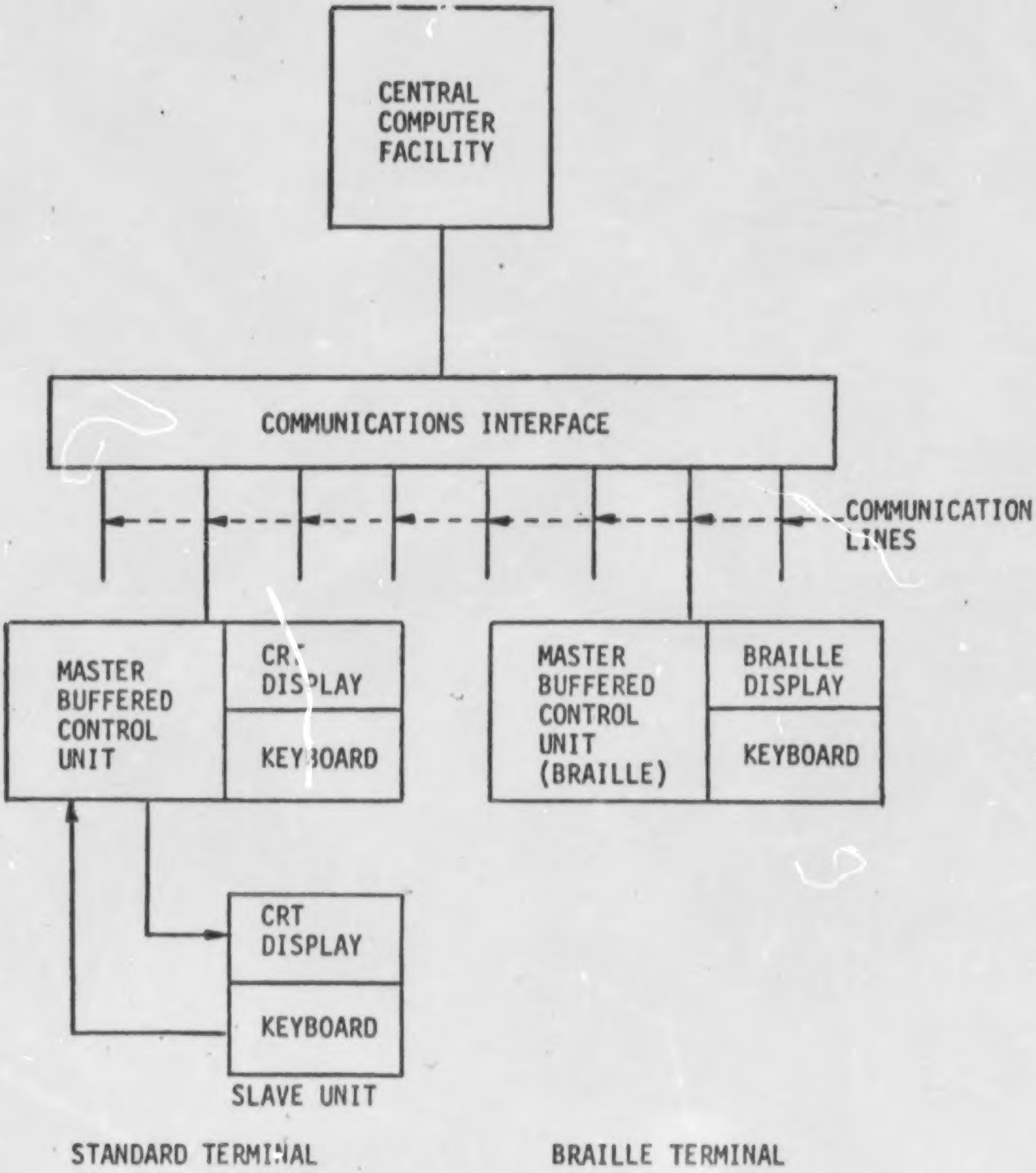
*The normal cursor "HOME" position refers to the first character position (character "1" on line "1") on the video "page".

At this time, at least four areas of application of the device are apparent:

1. Clerical positions in such areas as
    a. Airline reservation
    b. Order taking and inventory control
    c. Credit file searching
    d. Service representation.
2. Managerial positions involving decisions made on the basis of computer-based files.
3. Professional positions primarily in technical areas ranging from computer programming to computer work in science; other areas of science and engineering may also provide opportunities for utilization.
4. Computer Aided Instruction (CAI). In this area, the blind could be on a par with the sighted, and no distinction in the presentation of materials need be made.

As an example of how such a braille terminal might be used, consider an application with an airline reservation clerk. (Fig. 1 is a block diagram of how the braille terminal would be connected in place of a standard terminal.) Figure 2 shows a facsimile of a list of instructions for operations performed while interacting with a prospective customer (passenger) and a computer. During this interaction, the clerk communicates with the prospective customer via telephone and communicates with the computer via keyboard and terminal display. The computer, which has schedules, availability, and other supportive information stored in its memory, is programmed to selectively provide such parts of the available information as are specified by the operator.


CENTRAL COMPUTER FACILITY
COMMUNICATIONS INTERFACE
COMMUNICATION LINES
MASTER BUFFERED CONTROL UNIT
CRT DISPLAY
KEYBOARD
MASTER BUFFERED CONTROL UNIT (BRAILLE)
BRAILLE DISPLAY
KEYBOARD
CRT DISPLAY
KEYBOARD
SLAVE UNIT
STANDARD TERMINAL
BRAILLE TERMINAL

SYSTEM BLOCK DIAGRAM

FIGURE 1

THERE ARE 5 MANDATORY FIELDS IN BUILDING A PASSENGER RECORD. IF ANY ONE OF THEM IS DELETED, APOLLO WILL NOT ACCEPT THE RECORD:

I. ITINERARY FIELD
  A. Flight Segment - This consists of airline, flight #, class of service, date and month, origin, destination, action taken, # of seats, departure time, and arrival time.
  B. Auxiliary Services - This consists of hotel, car, tour, limo, etc. requests. Required information to enter it is the auxiliary code (htl,car,tur,lim,sur), airline, action taken, city, date and month.

II. NAME FIELD
  A. N:1 Maxwell/J — one surname
     N:1 Maxwell/J N:1 Roberts/T — more than one surname
  B. Cross-reference
  C. Name changes
  D. Infants

III. CONTACT FIELD
  A. P:CHIT/312 268-5540 x31/B/312 275-4830 - phone
  B. P:CHIA/Res/1221 N. Harlem Chicago Illinois 60047 -address

IV. TICKETING FIELD
  A. Ticketed
  B. PTA
  C. Revalidation
  D. Ticket by mail
  E. Ticket office will call
  F. Airport will call
  G. Teleticketing
  H. Other airline ticketing

V. GENERAL FACTS FIELD
  Information which is valuable to us but does not need to be transmitted to the airport or ticket counter.

VI. SUPPLEMENTARY INFORMATION FIELD
  Requests which require advance action or a reply.

VII. RECEIVED FIELD
  Identifies the caller

— Schedule changes are handled with special action codes within the itinerary. (uN,wK,Sc)

— To determine the path a certain flight travels enroute to its destination:
  VITflt.#/dateandmonth   example: VIT346/26Jan
  The response will be cities the flight goes to at the left and times of departure and arrival at each city on the right.

— SPLIT & DIVIDE - A function to divide a party of 2 or more into separate records.
  1) D1*3 -- Asking Apollo to give you only the first and third names out of the group of names.
  2) D1N(2Kelly/E/Mstr T -- Asking Apollo to give you Mr and son out of the rest of the family.

— FLIFO F:346\26Jan

FIGURE 2.

Instructions for airline reservation operations

The clerk, whether handicapped or not, would on request give the caller information on schedules, availability of reservations, known delays for particular flights, connections, ticket pricing, etc., all of which can be obtained from the computer in a programmed fashion. For instance, the operator may ask for the "first nonstop flight after 11 a.m. from Chicago to Boston with seats available." While interacting with the customer, the clerk can make preliminary entries in the computer memory (taking notes, as it were). After the customer has decided on a booking, the clerk will confirm (from his notes which he retrieves from the computer on his display) the details of the reservation to be made. He then enters the corresponding booking (the passenger record) in the computer by means of his keyboard and erases the notes from the computer memory, thereby completing the clerk's function.

In this kind of application, the information sent to and received from the computer is highly organized and coded; thus, the operator need not sift through a mass of data to obtain the answer to his inquiry, and the number of characters that need to be displayed and read is small. Consider for an example the following possible computer response for the above request: (First nonstop flight after 11 a.m. from Chicago to Boston).

```
11:00a    2:05p    UA    699    F/Y    D10    L    0
```

To request this output line and accompanying lines, the operators must first know the code for both departure and destination to type in as entering arguments (e.g., ORD is Chicago O'Hare Airport). This does not pose a serious problem to a blind operator any more than to a nonhandicapped person; as a matter of fact, he may be expected to be especially well prepared for responding to clues to information (which is almost synonomous with "decoding") by his usual daily chores. This would seem generally true because much of the information provided for in an environment designed for the seeing must be inferred indirectly ("decoded") by the blind. Furthermore, specifically the usage of Grade II Braille would appear to be conditioning beneficial in the outlined work situation: the Grade II code, relying on context of word and sentence structure and even on conceptual content of the message transmitted in the rules of usage, cannot but develop agility in dealing with abstract "languages".

To envision corresponding procedures in some detail, consider again an airline reservation desk; parts of an inquiry may concern questions such as "Is lunch served on the flight in question aboard a DC-10 aircraft?" This type of knowledge is acquired through normal operator training. Remember in the previous example that perhaps ten corresponding lines would be stored in the terminal memory; thus, the operator could specify which part of this information he wants to appear on the braille display. The operator could begin by hitting the "Home" key which sets readout to the beginning of the first line, hit the "Right" key to read across to the arrival time of 2:05 a.m., hit the "Down" key to column scan the arrival times, hit the "Carriage Return" key to start at the beginning of the desired line, and then hit "Right" again to read that line. The formatting for the above hypothetical operation should, of course, be carefully chosen, e.g., should "Right" and "Left" initiate continuous readout or the readout of a known group of characters.

While many answers must yet be determined and operator techniques must yet be developed, the authors feel that a braille computer terminal as described here could well provide employment and educational opportunities for the blind which have as yet been virtually untouched. The design of such a system does not seem to present insurmountable difficulties.

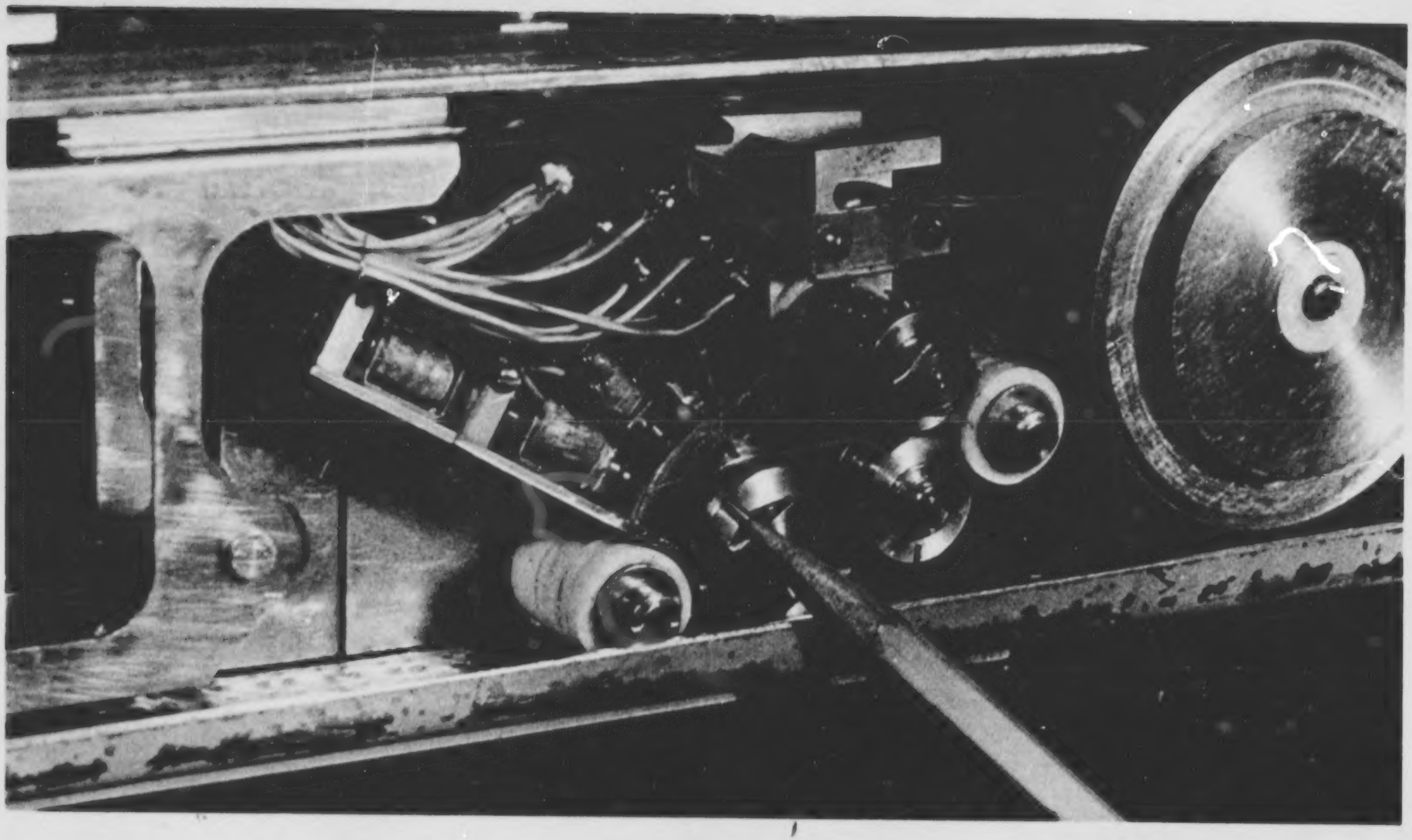


FIG. 3. BELT ERASING & WRITING STATION

The authors acknowledge that Mr. Robert Humbert of the American Assoc. of Workers for the Blind in Oakland, California has first alerted them to the potential of this application of the Argonne Braille Machine.

United Airlines has kindly provided us with valuable details of the environment and mode of operation of airline reservation facilities.

Dr. Lois Leffler and David Jacobson (of Applied Mathematics Division of ANL) participated in a preliminary study of the subject.

III-G-1

THE DEVELOPMENT OF A COMPUTERIZED GRADE II BRAILLE TRANSLATION ALGORITHM*

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SUMMARY

The development of a portable Braille reading device, the Argonne Braille Machine, as part of an automated Braille production and distribution system led to the writing of a computerized modular Braille translation system. The translation module, whose algorithm utilizes the list processing facilities of PL/I, has the capability of translating conventional inkprint text from one of several different sources into a form of Grade II Braille suitable for use by the Braille reader.

The computer translation of inkprint material into perfect Grade II Braille is a challenging problem. The translation of a given string of characters in a word depends upon their position and function in the word as well as their pronunciation. Further, the correct translation of some words depends upon their context. The algorithm currently implemented at Argonne National Laboratory follows the rules of Grade II Braille when possible. This algorithm represents a compromise between accuracy of translation and minimal core storage and execution time requirements. Current translation rates exceed 22,000 Braille characters per minute. Our ultimate criterion for "success," however, is user satisfaction. Future work will focus upon meeting that criterion.

INTRODUCTION

The Argonne Braille System

The development of a computerized Grade II Braille translation system was the outgrowth of a need for compact, timely, readily available, and low (real) cost Braille translations for use by the blind community. (See Appendices I and II.) The complete Argonne Braille Production and Distribution System represents an attempt to bring Braille material to the blind reader more compactly, quickly, and inexpensively than is possible by the present system. (See Appendix III.) The heart of the system is the Argonne Braille Machine. (See Appendix IV.) Briefly, this device, a portable Braille reader, causes information stored on a magnetic tape to be transformed into a continuous stream of corresponding Braille characters which are formed on a moving plastic belt. The reader places his fingertips on the belt, senses the Braille characters, and thereby reads. This paper describes the computer translation algorithm which was implemented to produce magnetic tape input for the Braille machine.

The Translation Algorithm

The translation algorithm was designed in a pragmatic manner. It was assumed that perfect Grade II Braille, for reasons to be discussed, would be impossible to achieve in a program which represented a practical compromise between program size, execution time, elapsed programming time, and accuracy. The theoretical question of whether a perfectly accurate translation is possible has not been investigated to our knowledge. It was therefore decided to make the user the ultimate judge of the quality of translation, as determined in a field test.

At present several excellent Grade II Braille translation programs exist, some of which are based upon different design philosophies than ours and which use different algorithms.[1,2,3] Much work has been done at MIT, the American Printing House, the IBM center in England, and Iowa State University. Unfortunately, however, the existing programs are most often written in machine or assembler language for machines other than the computer complex used at Argonne National Laboratory, and several are highly specialized programs. All would be rather difficult to modify to suit the needs of the Argonne Braille Machine system. The Argonne Braille Machine does not require any hyphenation as it produces a continuous stream of Braille, hence the non-trivial programming problem of providing hyphenation at the end of a line is avoided. Further, the Argonne Braille Machine requires a unique digitized format for the information which it reads. We therefore chose to write our own translator.

Braille as a Computer Problem

Grade II Braille presents a difficult and interesting computer translation problem. It is the form of Braille in common use and the language chosen for the Argonne Braille Machine system. In Grade II Braille the same sequence of letters may be translated differently depending upon its position and function in the word and its pronunciation. Further, some translation rules are based upon context.[4,5,6] The following discussion provides some examples of problems which are difficult or impossible to solve for all cases with a computer program. The imperfect Grade II Braille produced by the

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*Presented at Western Electric Show and Convention, San Francisco, 1971.

translator is due to these types of problems.

1. Contextual Rules. A Grade II symbol exists for the word "of." In the sentence, "I will give the girl I am fond of a new Ford", the contraction for the word "of" may not be used because the preposition "of" is not followed by its object.

If one considers the "context" of letters, one runs into other interesting problems. For instance some words are actually acronyms, e.g. "SEATO." Here the "ea" contraction, ordinarily used in a word containing those letters, may not be used. Finally, consider the context of a part of a word. There exist in Grade II Braille some short-form words. For example the word "little" is represented in Braille by "ll." These words may be used in Braille either as stand-alone words or as part of another word, unless the word is a proper name. In the name Jimmy Doolittle the Braille contraction for "little" may not be used.

2. Pronunciation-based Rules. In the word "airedale" the "ed" contraction may not be used because it would cause pronunciation difficulties. In words like "evert" and "sphere" the contractions "ever" and "here" are not allowed, as they do not retain their own sound.

3. Rules Based upon Position and Function. The contraction for the word "of" may be used within a word under some circumstances. In the word "profit" the "of" contraction is used. In the word "professor" the "of" contraction may not be used because the contraction would occur across the boundary between the prefix and the stem of the word. Similarly, the "ed" contraction may not be used in the word "freedom" because it would also cross a base word and its suffix. The "th" contraction may be used in words like "month" but may not be used in the word "porthole." In this case the contraction would be used across the parts of a compound word.

Other rules merely make the program's execution time longer and the programming more difficult. For instance, one such rule states that two or more lower signs, signs that utilize only the lower part of the Braille cell, must not follow each other without an intervening space unless there is a Braille cell having dots in one of the uppermost positions in contact with them.

Another rule states that the contraction that saves the most space must be used. Some Grade II Braille contractions occupy more than one Braille cell. A rule states that a one-cell contraction must be used unless the two-cell contraction would save more space.

There are other "problem" rules but the examples given suffice to illustrate the point.

Some of the above problems can be handled by clever programming techniques. In other cases the use of a dictionary containing suitable words or fragments of words will ensure correct translation most of the time.[7] However, both clever programming and a large dictionary have large overheads in the form of core storage and execution time requirements.

Braille rules are presently set by the Braille Authority. Changes in American Braille are constantly being suggested and some few ultimately find their way into the Braille Standards. A recent M.S. thesis[8] proposes some appropriate changes. Recently, individuals familiar with the problems of Braille translation by computer have been asked to consult with the Authority. Hopefully, future changes in the Standards will reflect the requirements of computerized translation.

ARGONNE BRAILLE TRANSLATION SYSTEM

Design Philosophy

Three main objectives were kept in mind as the Braille translation system was designed: the computer system was to be modular, it was to be easily modified, and it was to give as perfect Grade II literary Braille as possible. It was also to be efficient and require minimal core storage. However, this was a secondary consideration in the initial design.

Several types of input were envisaged for the Argonne Braille translation system. These included optical scanning devices; automatic typesetting or compositor tape systems such as the Teletypesetter system (TTS), the Monotype system, or any of the other thirty-odd proprietary systems in use today; the conventional keypunch system (which was the first system actually used to prepare input for the translator); the MT/ST or Flex-o-Writer; and the more recent key-to-tape or key-to-disk systems. Having each different input system handled by its own module means that all input can go to the same translator module. If, further, the translator module is separate from the dictionary, the dictionary can easily be modified without changing or recompiling the entire program system. Finally if the proofreading, analysis, and computer Braille modules are separate these functions can be used or omitted as desired.

The modular approach was also helpful in meeting our second design goal--that the system be easily modifiable. This approach means that only the module needing changes must be handled and recompiled. Coding the dictionary separately allows it to be easily modified without recompilation. The use of a higher-level language, besides making the initial programming effort easier, means that subsequent programmers can more easily modify the program at the source language level.

The PL/I language was chosen because of its character handling and list processing facilities. PL/I is sufficiently flexible and complete that its logic can easily serve as a guide to machine language or other-language versions of the program.

The blind reader is to be the ultimate judge of the quality of the Braille produced; the computer translation must be acceptable to him. Grade II Braille has some slight ambiguities which could allow stylistic variation. They are to be resolved in favor of ease of programming. If clear-cut rules exist the translator, if at all possible, is to give the correct translation. Words and phrases used frequently must be accurately translated. As previously mentioned, it is necessary to balance the need for perfect Braille with the necessity of keeping the program as efficient and compact as possible. It is expected that the feedback which is obtained from users during the field test will dictate certain changes to make the Braille produced by the programs completely acceptable to them.

Program Architecture

The purpose of the input modules is to prepare material for the translator. At present modules have been prepared for three different types of input: the keypunch, the Teletypesetter system used by Time-Life Incorporated, and the compositor tape system used by Rocappi, Inc. Each input module takes input on punched cards or magnetic tapes, inserts special characters to flag certain conditions for the translator, and strips out unwanted characters. This is particularly necessary in the case of the compositor systems, as the tapes contain control information for the typesetting machines which is neither wanted nor needed by the Braille translator.

The output from each input module is given to the translator as a group of characters terminated by a blank. This is assumed to be a word. The word is first considered as a whole in the dictionary search and is broken down into smaller units only if necessary. It is considered as a series of individual characters as a last resort.

The dictionary cell corresponding to a valid Braille unit contains decision information in the form of a bit string made up of "1's" and "0's." Conventional decision-making processes (IF statements) are used to determine if the use of a Braille contraction is appropriate.

The output of the translation program consists of groups of eight bits referred to as Braille equivalents. The first six bits of each group indicate the presence or absence of a raised dot in a specific matrix position. The seventh bit is a parity bit, and the eighth bit may be used to signal the presence of indexing information to the succeeding modules.

Dictionary Construction

A major problem facing the programmer is the construction of a structure--called a dictionary--containing the appropriate inkprint characters and their Braille equivalents. Advantage was taken of the PL/1 list processing techniques to construct a dictionary in binary tree form. The dictionary generating program builds the dictionary, taking advantage of the system's collating sequence and allocating space for dictionary entries only as necessary. This is illustrated in the following example. Consider a list of prospective dictionary entries *wh*, *a*, *w*, *and*, *with*, *b*, *but*, and the *'blank' character*, with their associated Braille equivalents and decision information.

Each dictionary cell contains a pointer to the preceding cell, two pointers to the following cells, a single alphanumeric character entry, a decision code entry which characterizes the usage of a given Braille representation, and a Braille character entry of varying length (omitted if the corresponding chain has not been assigned a sequence of Braille characters). Using a binary tree structure to represent the above dictionary list, with circles representing each cell and arrows indicating pointers, one has the structure represented in Figure 1. Braille equivalents and decision information would be stored in the double-circled cells, which correspond to valid Braille characters or contractions.

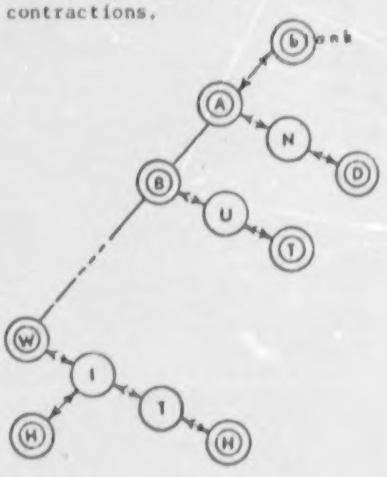

Fig. 1. A Sample Dictionary Structure.

In the course of scanning the text to be translated, one might find the word "with." One would then start down the dictionary list looking for "W," branching to the right when agreement was found and to the left if no agreement were found at each circle. In this way one would proceed past "blank," "A," "B,"...,down to "W." The next letter, "I," would then be sought by going to the right. After it is found, the "T" and then "H" are sought and located again by progressing to the right. At the final position, "H," corresponding to the end of the word to be translated, a check is made for a Braille equivalent and decision information. If these were not found or if the use of the Braille equivalent were not permitted, one would retrace his steps upwards to "T," "I," and "W" until a Braille equivalent and appropriate decision information were found in a cell.

To give a second example, at another point in the translation one might encounter the word "whence." In this case one would find the "W" as before. However, on proceeding to the right the next letter encountered is "I." One is searching for "H" so one branches to the left from the "I." There "H" is found and no pointers are found to any further entries. In this case appropriate decision entries and Braille equivalents are found with the "H" so the Braille equivalent of "WH" is then obtained, and the search for "ENCE" is instituted from the top of the tree structure as before.

This dictionary structure presently contains punctuation marks, special symbols, groups of characters and words for which Braille contractions exist, the numerals 0 through 9, and finally words and word fragments which are incorrectly translated by the present algorithm.

The present program scans the word from the left. We hope to investigate further the possibility that accuracy in translation would be enhanced if one were to work from right to left rather than left to right, or that a combination of both searching techniques would be advantageous.

Retranslation Facility

One further module has been incorporated into the basic translation package. This takes the digitized Braille output and retranslates it into inkprint and a representation of Braille output (utilizing the period to signify a raised dot) for the purposes of obtaining statistical information about the frequency of usage of the various contractions and symbols used in Braille and for proofreading purposes. Contractions are indicated by vertical placement of the letters of the contraction under the Braille output. (See Figure 2.) This output is for the benefit of the sighted proofreader. In another version of the module, Braille is produced on the line printer in the form of raised dots for the benefit of blind readers. No attempt is made to divide words at the end of lines because of the nature of the system under consideration. In the Argonne Braille Machine the concept of a "line" is meaningless and words are therefore never divided.

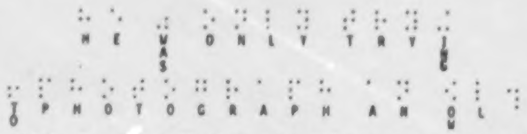

Fig. 2. Output from the Retranslate Module

The input to the retranslation step consists of strings of eight binary digits, the first six of which represent the presence or absence of Braille dots. Each group of six digits is considered to be a binary number (labelled "SUB") and is used as a subscript in an array of 64 statement labels (called "LABELS"). The PL/1 statement "GO TO LABELS (SUB)" then sends the execution process to the proper section of the program. At this point the translation of the Braille character is accomplished and the Braille cell is assembled. When appropriate, an entire line of Braille representations and inkprint equivalents is printed out. Advantage has been taken of decision table techniques to determine the translation of each Braille character.

At the time the translation is accomplished the appropriate counter is incremented to indicate the use of a particular contraction. At the end of the retranslation process the value of each counter is printed out, along with the identification of the contraction for which it is used.

Future Work

A field test of the Braille Machine is planned for 1972. The results of the field test will govern the future direction of work on the translation algorithm. The field test will enable analyses to be made concerning

1. the acceptability to the blind reader of the Braille produced,

2. an indication of changes to be made in the algorithms, and

3. unanticipated problem areas which must be considered.

Our current efforts are directed toward producing Braille machine tapes for this test. In the process of tape preparation preliminary error counts and statistical analyses are being made. Our present Braille translation rates reach approximately 22,000 Braille characters per minute using the IBM System 360/50-75. It is hoped that these rates can be improved when we have produced Braille that is acceptable to the blind reader. Studies exist[9,10] which analyze the frequency and context of usage for the various Braille contractions. These data will be most helpful in our efforts to optimize our program and the associated dictionary.

In the context of the total production and distribution system, cost-benefit analyses must be made to determine, among other things, the suitability of mini-computers versus large time-shared systems, the acceptability of "nearly correct" Braille as opposed to perfect Braille, and the best form of textual input to the tape production system. Ultimately it is planned that by using this system the blind reader will enjoy the same advantages that a sighted reader takes for granted.

ACKNOWLEDGMENTS

This work represents the efforts of an interdisciplinary group of scientists, engineers, and technicians of different research divisions of Argonne National Laboratory, led by Arnold Grunwald of the Laboratory's Engineering and Technology Division. He is interested in the systems aspects of the project as well as the mechanical requirements of the machine. William P. Lidinsky of the Applied Mathematics Division has been primarily responsible for the development of the data handling and the electronic systems of the machine. Lois Leffler has been responsible for the computer system development.

Several others have made significant contributions to the programming efforts. S. M. Prastein assisted in the early stages of the computer system design. Mary R. Ellis assisted in the debugging and documentation of the translation modules working under separate grant. Cynthia C. Chamot and Peter Grunwald programmed the Rocappi and TTS modules. Peter Grunwald and Judith Chernick served as unpaid Braille consultants and proofreaders.

The development of this system is being supported by the Department of Health, Education, and Welfare, Office of Education, under contract OEG-0-9-080144-4280(032) "A System for Compact Storage of Information on Magnetic Tape, Readable by Touch as Braille Characters by Means of a Portable Reading Machine."

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1. *Final Report, Computer Translation: Grade 2 Braille from Print*, Ann Schack, Joseph Schack, Robert Haynes, and John Siems, The American Printing House for the Blind, Louisville, Kentucky, June 1969.

2. *Dotsys II, Finite-state Syntax Directed Braille Translation*, J. K. Millen, the Mitre Corporation, July 1970.

3. *The Translation, Production, and Dissemination of Documents in Braille*, pp. 351-381, by R. E. LaGrone, Information Systems Symposium, Washington, D.C., 1968.

4. *Instruction Manual for Braille Transcribing*, Third Edition, Division for the Blind and Physically Handicapped, Library of Congress, Washington, D.C. 20542 (1967).

5. *Transcribers' Guide to English Braille*, Bernard M. Krebs, the Jewish Guild for the Blind, 1880 Broadway, New York, New York (1969).

6. *English Braille, American Edition, 1959 as Revised 1962, 1966*, American Printing House for the Blind, Louisville, Kentucky (1966).

7. *The Mechanical Transcription of Braille*, from "Mechanical Resolution of Linguistic Problems," A. D. Booth, L. Brandwood, J. P. Cleave, 1958, Butterworths Scientific Publications, London, and

   Braille Transcription and Mechanical Translation from "Mechanical Translation," 2 (3), 50-54, December, 1955.

8. *A Study of Braille Code Revisions*, Gerald Francis Staack, M.S. Thesis, Department of Mechanical Engineering, MIT, August 1962.

9. *Report of the Survey of the Frequency of All the Contractions of Standard English Braille Grade II*, H. M. Lochhead, J. Loumer, Scottish Braille Press, Craigmillar Park, Edinburgh, 9, Scotland, transcribed from Braille by Peter Grunwald.

10. *Key Braille Contraction Contexts*, American Printing House for the Blind, Louisville, Kentucky, 1969.

* * *

APPENDIX A

BRAILLE AS A LANGUAGE

Braille was invented by Louis Braille, a blind student in a Parisian school for the blind, in 1829. Each Braille character consists of raised dots in a three by two matrix of dot positions. (See Figure A1) By sensing the presence or absence of these dots with his finger tips a blind individual reads.

There are several grades of English Braille. The so-called Grade I Braille is a one-to-one inkprint to Braille translation. One or, infrequently, two Braille characters corresponds to one inkprint character. There are special characters to indicate numbers or capitalization.

Grade I Braille presents a trivial translation problem for the computer. However, it is extremely bulky and therefore is rarely used.

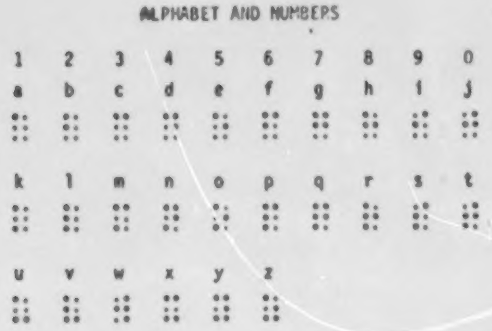

Fig. A1. Grade I English Braille.

Grade II Braille, on the other hand, may translate several inkprint characters into one Braille symbol. Some compression of the resulting Braille text is achieved with Grade II Braille. The average English word is approximately 5.5 characters long, including the space. The average Grade II Braille word is 4.2 characters long, including the space. A given Braille symbol can have many meanings depending upon the surrounding Braille cells, since only 64 possibilities exist for distinct dot configurations in a 3x2 matrix.

Still other forms of Braille exist. Grade III Braille is highly contracted, a shorthand, and is not generally used. Other special-purpose Brailles are used by small numbers of individuals. Two notable exceptions are encountered, the Braille used for music transcription and the Nemeth Code of Braille Mathematics.[1] These two systems are in relatively common usage and present unique problems, thereby necessitating special handling in a computerized system.[2] The number of volunteers skilled in the transcription of these languages is even smaller than the number of those available for the transcription of general literature.

Braille is not universally used by the blind population. For some there is no opportunity to learn this method. For others, especially the aged, it is too difficult to learn. The present scarcity of Braille materials causes many to become discouraged from learning it, or to lose their skill once it is learned.

It has often been suggested that "Talking Books" provide an alternative means of communication. For some purposes they are indeed ideal, but for many blind individuals they are not. The passive role forced upon a listener and the relative slowness with which information is communicated, as well as the lack of privacy and the potential interferences with and by peripheral or competing sounds hinders this method of communication. There seems to be no substitute for being "literate." For the student or professional, especially, Braille is indispensable. Imagine for a moment a sighted professional who is not allowed access to technical books or professional journals! Braille, if readily available, provides the blind with advantages comparable to the ones that inkprint provides for the sighted.

Other means of communication are being developed.[3] Many of these attempt to replace the eye with an electronic equivalent. Further progress may be expected in the future; however, the scarcity, expense, bulk and complexity of these devices make them inaccessible to most blind individuals at this time.

REFERENCES FOR APPENDIX A

1. *The Nemeth Code of Braille Mathematics and Scientific Notation*, American Printing House for the Blind, Louisville, Kentucky, 1969.

2. *Final Report, Computer Translation: Grade 2 Braille from Print*, Ann Schack, Joseph Schack, Robert Haynes, and John Siems, The American Printing House for the Blind, Louisville, Kentucky, June 1969.

3. See for example:

   Personal Reading Machines: How They Work, What They can Do, The New Outlook, 63, 257-261, November, 1969.

   Human Factors Underlying the Design of Reading Aids for the Blind, Patrick W. Nye, IEEE Transactions on Bio-Medical Engineering, BME-17, No. 2, 97-100, April 1970.

   Blindness, Modern Approaches to the Unseen Environment, Paul A. Zahl, Editor, Hafner Publishing Company, New York, 1962.

   A Monolithic Image Sensor for a Reading Aid for the Blind, Phillip J. Salsbury, James D. Meindl, Proceedings of the IEEE, 58, 1302-1314, September 1970.

* * *

APPENDIX B

THE PRESENT BRAILLE PRODUCTION SYSTEM

Some Braille translations are now made by volunteers, who often belong to organizations such as the Johanna Bureau for the Blind and Visually Handicapped of Chicago. These individuals usually make a single copy upon request by a blind reader. The original is usually stored by the organization and a Thermaform copy is made for the requester. The cost of making the copy is very high.

Braille is also produced by Howe Press in Boston, Clovernook Printing House for the Blind in Cincinnati, the federally-supported American Printing House for the Blind in Louisville, Kentucky, and others. These organizations use paid human translators. The American Printing House also uses a computer-based translation system. Braille is produced on metal plates which are then used to produce multiple copies of widely requested materials.

In both systems real costs are high and the resulting Braille documents, even when contracted forms of Braille notation are used, are extremely bulky (averaging fifty times the volume of equivalent inkprint materials). In addition, one organization sometimes does not know the materials another organization has available. The turnaround time for delivery of materials is long since work often is not begun until a request for a specific item is received. The situation is further complicated by the fact that it takes about two years to train a volunteer Braillist and not nearly enough volunteers are available.

* * *

APPENDIX C

THE ARGONNE BRAILLE PRODUCTION AND DISTRIBUTION SYSTEM

An entire Braille production and distribution system which will incorporate the Argonne Braille Machine is being defined. The goal of this system is to reduce the speed and cost problems inherent in the present Braille translation and distribution system by using a computerized translation process to prepare tapes for the Argonne Braille Machine. (See Figure C1) The computerized translation system would increase the rate of translation of text into Grade II Braille.

The following types of input to the computer translation program can be used.

1) Computer compatible type-setting tapes which are already in use in the printing industry.

2) Optical character recognition devices which scan printed pages and prepare input for the translation program. Previously Brailled material could also be scanned and reformatted for the Braille machine.

3) Keyed devices, such as the MT/ST, the Flex-o-Writer, and the keypunch. Their use would alleviate the problem of too few volunteer Braillists.

The computer output would be placed on quarter-inch magnetic tape for input to the Argonne Braille Machine. This would have two advantages. First, the excessive physical bulk of Braille material would be overcome. Five hundred pages of ink print would fit on a 3½" reel of tape and still allow sufficient space for voluminous reader's notes. Second, the cost of making single as well as multiple copies would be trivial.

Another alternative being seriously considered would be that of a skilled Braillist using the machine's keyboard to produce magnetic tapes directly. An unpublished study conducted at Argonne and results reported by MIT and the American Printing House[1] have indicated severe problems to be overcome before use of typesetting tapes will become practical. The fact that less than perfect Braille is produced by present translation programs already implies the use of Braille proofreaders at some time during the production process. The same individuals might well be involved in both activities.

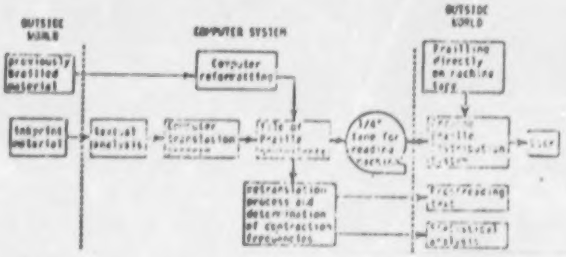
OUTSIDE WORLD
COMPUTER SYSTEM
OUTSIDE WORLD
previously Brailled material
Computer reformatting
Brailling directly on machine tape
Inkprint material
Textual analysis
Computer translation program
File of Braille
1/4" tape for reading machine
Braille distribution system
User
Retranslation process and determination of contraction frequencies
Proofreading test
Statistical analysis

Fig. C1. The Argonne Braille Production and Distribution System.

REFERENCE FOR APPENDIX C

1. *Final Report to Social Rehabilitation Administration, Department of Health, Education and Welfare of work under contract SAV-1057-67 for the period 1 December 1967 through 31 December 1968*, Sensory Aids Evaluation and Development Center, MIT, 30 April 1969.

* * *

APPENDIX D

THE ARGONNE BRAILLE MACHINE

The Argonne Braille Machine translates information on magnetic tape into Braille characters which appear on a moving plastic belt, where they may be sensed by the fingertips. After having passed under the reader's fingers the Braille characters are erased and the belt is then prepared to receive other characters. The self-contained unit (see Figure D1) fits easily into an attaché case.[1] It consists of a specially designed incremental magnetic tape transport which handles standard 1/4-inch magnetic tape, an "endless belt" Braille display unit with its associated embossing and erasing mechanism, read-write electronics for the magnetic tape, an electronic memory and control package, a power supply, and an optional battery pack. Also included, though omitted from the picture, is a keyboard which activates the write electronics.

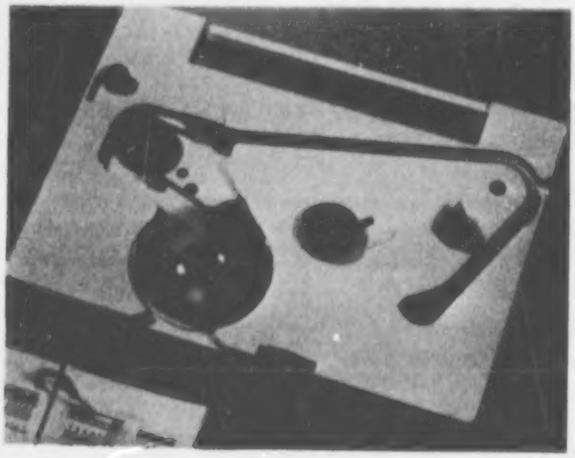

Fig. D1. The Argonne Braille Machine.

The machine features a "dead man's" switch. Automatic page skipping, a text annotating facility, and variable speed operation are also incorporated into its design. The Braille reader may suit his reading speed to the material and attain Braille reading speeds of from approximately 50 to 320 words per minute.[2]

As pictured and described below, three types of characters separated by ID bits and bracket pulses may be recorded in any order upon the magnetic tape. Bracket pulses serve a clocking function in the machine's logic and control circuitry. ID bits serve to identify the characters needed for the desired mode of operation, depending upon whether the user has elected to read text, read notes, write notes, or locate specific information. In each mode one character type is recognized and the others are ignored. (See Figure D2)

Book characters are handled by the machine in a "read only" manner, in contrast to the note characters described below. Both the book characters and note characters cause information from the magnetic tape to appear as corresponding Braille characters upon the moving plastic belt.

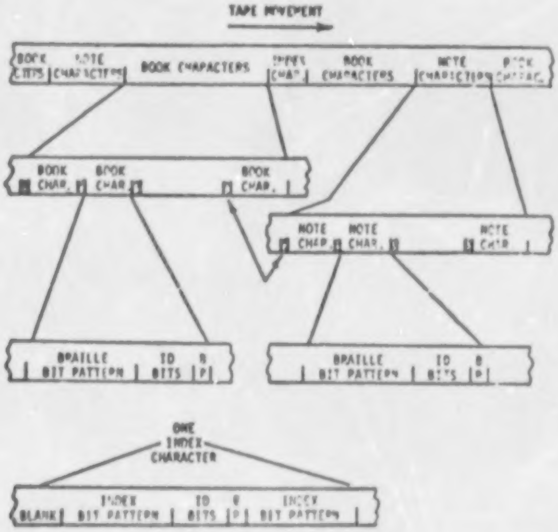
TAPE MOVEMENT
BOOK CHRS
NOTE CHARACTERS
BOOK CHARACTERS
INDEX CHAR.
BOOK CHARACTERS
NOTE CHARACTERS
BOOK CHARAC.
BOOK CHAR.
BOOK CHAR.
BOOK CHAR.
NOTE CHAR.
NOTE CHAR.
NOTE CHAR.
BRAILLE BIT PATTERN
ID BITS
B P
BRAILLE BIT PATTERN
ID BITS
B P
ONE INDEX CHARACTER
BLANK
INDEX BIT PATTERN
ID BITS
B P
INDEX BIT PATTERN

Fig. D2. Magnetic Tape Formats

Index characters, like page numbers in conventional text, allow a reader to search rapidly and automatically for specific items in a forward or backward motion using a pre-set counter.

Note characters may be placed in blank spaces (interleaved with the text on the magnetic tape) by the operator, using the machine's keyboard. They correspond to the written notes a sighted person would place in the margins of an inkprint text. These notes may be freely altered by the user. The machine thus may be used also for correspondence, notes, or anything else for which a sighted person would use writing materials.

REFERENCES FOR APPENDIX D

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2. *A Braille-Reading Machine*, Arnold P. Grunwald, Science 154, 144-146 (1966).

THE ARGONNE BRAILLE TRANSLATOR

Lois C. Leffler and S. Matthew Prastein

ANL T.M. 180, May 1969

The Argonne Braille Translator, designed as part of the Argonne Braille Machine System, has as its objective the transformation of typesetter-oriented input into Braille Machine-oriented output. The input is material which would normally be produced by the publisher at some stage in the conventional processing of inkprint text (such as monotype paper tape or a magnetic tape replica thereof). The output is a master magnetic tape, suitable for control of the replication of tape for the Braille Machine.

Input

To achieve overall economy in the production of such limited distribution material as braille, it is essential that the input costs be made mimimal. This may be done by using, as input, material which is normally produced at some stage of the conventional publishing process. Control tapes for automatic typesetting equipment are an obvious first thought; eventually one may wish to use control tapes for computer-driven CRT displays, should they become of widespread application.

The use of character recognition devices does not at present seem feasible. The lack of flexibility of available machines, combined with the economies of their use, render them unsuitable for a system whose aim is low-cost reproduction of a wide range of materials. This situation could change in the future, but there do not seem to be any immediate prospects of its doing so.

The control language of typesetting tapes contains a great deal of page formatting information that is irrelevant to the particular reader system being developed here. The Argonne Braille Machine[1-3] uses stream rather than page or line organization for its output, and therefore it is necessary to strip out the superfluous line and page structure information before proceeding to the braille translation proper.

The Target Language

Grade II Braille is a language intimately related to inkprint English,[4-8] but differing from it in important respects. Aside from superficial characteristics arising from the physical format and minor stylistic variations, Grade II Braille's most obvious differences from inkprint involve the substitution of abbreviations for individual words, syllables, trigraphs, diagraphs, and groups of inkprint characters. These substitutions are not always made in a simple one-to-one manner; considerations of usage, etymology, and syllabification are frequently involved. The situation is complicated by a residual (although small) ambiguity in the specifications for Grade II Braille, and there is some variation among expert translators in their interpretation of Grade II Braille specifications. It should be remarked, however, that these difficulties and ambiguities are one-way; there does not appear to be any serious impediment in the translation from Grade II Braille to inkprint.

There exist at present several excellent programs to translate compositer tapes to Grade II Braille, one example being that of A. and J. Schack.[9-15] Unfortunately, however, they are uniformly written in machine or assembly language and hence not only are tied to a particular machine but also are rather difficult to modify to suit the needs of the overall Argonne Braille Machine System. We have, therefore, chosen to write our own translator rather than attempt to adapt an existing program to our specific needs.

Translator Facilities

Expert human translators achieve a high degree of uniformity in their translations to Grade II Braille. It is probably not possible, at this time, to achieve perfection in machine translation to braille given the restrictions imposed by finite machine memory and speed. It is, however, essential to produce an *acceptable* level of translation. What constitutes an acceptable error rate must still be determined. One error per 500-word page is probably too much to be tolerated by a proficient braille reader, while one per 5,000 words is probably acceptable (depending, of course, on context).

The translator has, at present, the following capabilities:

1. Conversion of TTS monotype tape (magnetic tape replica) to stream text (output as a listing, on puched cards, on tape, or on a direct access device).

2. Translation of stream text to Grade I Braille (letter-for-letter, one-to-one; no contractions), including alphabetic characters, numerals, punctuation marks, and braille composition signs.

3. Translation of stream text to limited Grade II Braille.
   a. Word-group combinations involving of, the, for, with, and.
   b. Initial letter contractions.
   c. Words requiring special attention.

4. Retranslation of braille to inkprint.
   a. Printout of braille and inkprint text.
   b. Listing of contractions used.

5. Braille printout on paper.

6. Compilation of statistics.

Proposed Further Development

The current limited capability of our translator with respect to Grade II Braille includes, in skeleton form, all the facilities required for a complete translation system. Its structure is such as to be readily expandable to fully implement the Grade II Braille specifications. The next development phase, for which support is now being requested, will provide for:

1. The remaining Grade II Braille contractions.
2. Expansion of the exceptions dictionary.
3. Interpretation of statistics on contraction usage.
4. Optimization of the translation algorithm.
5. Collection of timing data, preparation of cost estimates, and comparison with performance of other translators.
6. Comparison to be made of overall costs for producing and distributing braille literature in the conventional way, relative to those for using the computer-based Argonne Braille Machine System. Costs would include estimates for a typical organizational scheme, including mechanisms for relaying user requests for materials and necessary distribution system for machines and tapes.
7. Detailed attention to be paid to problems of simultaneous minimization of translation error and of human intervention in the translation process.

Our design philosophy can be summarized briefly:

1. High-frequency words and phrases must be accurately translated in conformity with the specifications of Grade II Braille.

2. The finished translation must be acceptable to users who are proficient in braille.
3. Stylistic (as opposed to linguistic) ambiguities must be resolved in favor of convenience in programming.
4. Specification of the translation algorithm must be governed by information in the literature with respect to frequencies of word usage in standard English text. The frequency data can be used in specifying the contractions to be searched for and in determining which high-frequency words should be included in the exception dictionary. A simplified version of Nemeth's syllabification rules should be evaluated for its utility in the context of this translator.
5. Output must be tested by representative braille users. The algorithm and dictionary should be modified as necessary to ensure readability and user acceptance.

Program Architecture

Program flexibility and ease of modification have been achieved through modular design and use of PL/1 as the programming language. Separate procedures are used for interpretation of primary input, diagnostic analysis, dictionary definition, translation to Grade II Braille, retranslation, and for master tape output. Translation is via a dictionary of single characters, groups of characters, diagraphs, trigraphs, and higher-order structures. The list-processing facilities of PL/1 make possible an efficient algorithm for dictionary search, and the dictionary is readily expanded or contracted, without recompilation, with no loss of efficiency.

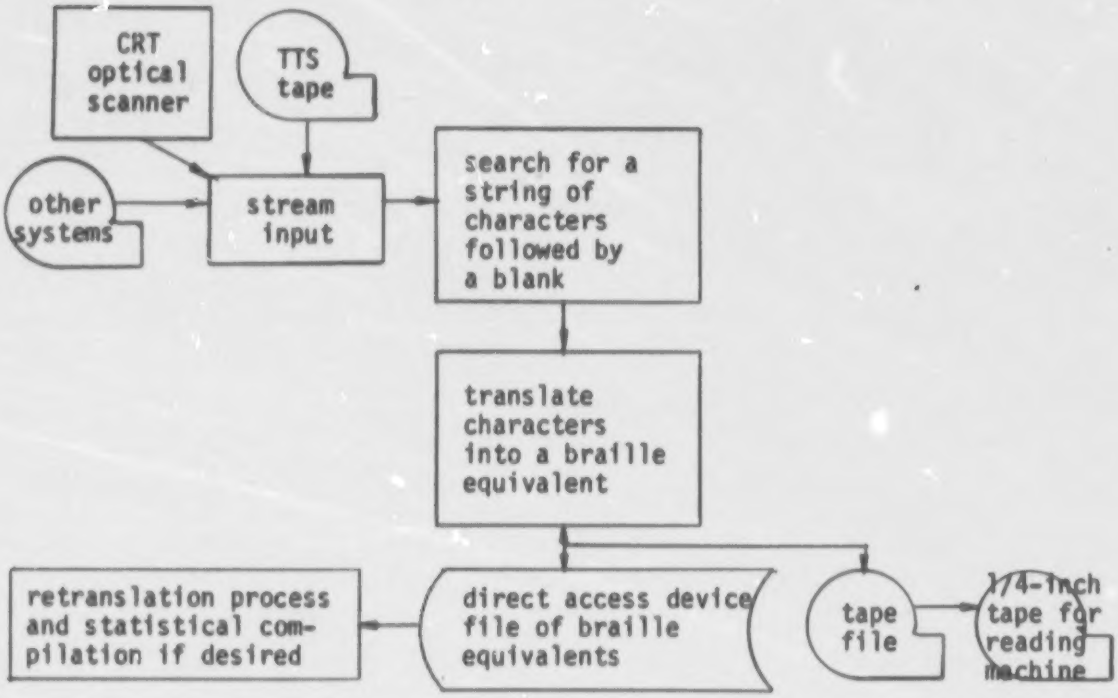
Modifications in other parts of the Braille Machine system, such as changes in the format of the final tapes or differing conventions in commercial automatic typesetting systems, are readily accommodated.

We have not attempted at this stage to produce code which would run on a minimal machine. The PL/1 object code produced requires an IBM System/360 machine running under O/S (with a minimum of 64K of core). Compilation to produce object code will be slow unless a considerably larger machine is used, but there should be no loss in efficiency in running the compiled program on a smaller S/360 machine. Dictionary modification can be done rapidly on a small machine since it does not require recompilation. PL/1 is a flexible enough language that the source code can serve as an outline or logic diagram for coding an equivalent program in machine language, or perhaps COBOL, for a small machine.

APPENDIX

PROGRAM DESCRIPTION

Logic Flow for the Argonne Braille Translation System


CRT optical scanner
TTS tape
other systems
stream input
search for a string of characters followed by a blank
translate characters into a braille equivalent
retranslation process and statistical compilation if desired
direct access device file of braille equivalents
tape file
1/4-inch tape for reading machine

PROGRAMMING CONSIDERATIONS

A. Input to the Translation Program - Use of Automatic Typesetting Control Tapes

A magnetic tape version of a TTS monotype tape containing an issue of Sports Illustrated was furnished to Argonne National Laboratory by Time, Inc. through their agent, R. R. Donnelley and Sons, for use in the development of the Argonne Braille Translator. This tape also contains information unique to the monotype system, and page formatting information, neither of which is needed in the Argonne system. Programs are currently being written to strip out unwanted information and to convert the TTS tape into stream input. This facility will be placed in an input module, and the operator will indicate to the system which type of input is to be used by the removal or insertion of appropriate small decks in the complete program deck.

At the present stage of development of this section of the translation system, no intractable problems seem to be facing the programmer. The magnetic tape and all necessary translation information are available and the programming is proceeding.

B. Translation Facility

The input from the TTS tape or keypunch is fed to the translation program as a group of characters terminated by a blank. The word is first considered as a whole in the dictionary search, if necessary broken down into smaller units from left to right, and is only as a last resort considered as a series of individual characters. The dictionary cell corresponding to a "valid" braille unit contains decision information in the form of a bit string containing 1's and 0's indicating whether a given condition must be true or false for the use of a given braille character to be permitted. Ultimately, it is planned that rule-masking techniques will be used to implement decision table documentation in the translation program. The program structure allows for this to be done. At present, conventional decision-making processes (IF statements) are being used on the individual rule bits. The conversion to the more efficient technique is expected to be easily accomplished.

The output of the translation program consists of a string of groups of 8 bits. The first 6 bits represent the braille character in digitized form, i.e., a 1 represents the presence of a raised dot, a 0 the absence of such a dot. The 7th bit is a parity bit used internally by the reading machine for error checking purposes, while the 8th bit can ultimately be used to signal the presence of indexing information in the other 7 bits rather than the usual braille information described above.

C. Dictionary Construction

A major problem facing the programmer is the construction of a structure -- called a dictionary-- containing the appropriate inkprint characters and their braille equivalents. Advantage was taken of the PL/1 list processing techniques to construct a dictionary in binary tree form. The generation program builds the dictionary, taking advantage of the system's collating sequence, allocating space for dictionary entries only as necessary. This can be made clearer by the following example: Consider a list of prospective dictionary entries wh, a, w, and, with, b, but, and 'blank' character, with their associated braille equivalents and implied decision code entries if the latter entries are applicable.

Each dictionary cell contains a pointer to the preceding cell, 2 pointers to the following cell, a single alphanumeric character entry, a decision code entry which characterizes the usage of a given braille representation, and a braille character entry of varying length (omitted if the chain has not been assigned a corresponding sequence of braille characters). Using a binary tree structure to represent the above dictionary list, with circles representing each cell and arrows indicating pointers, one has:

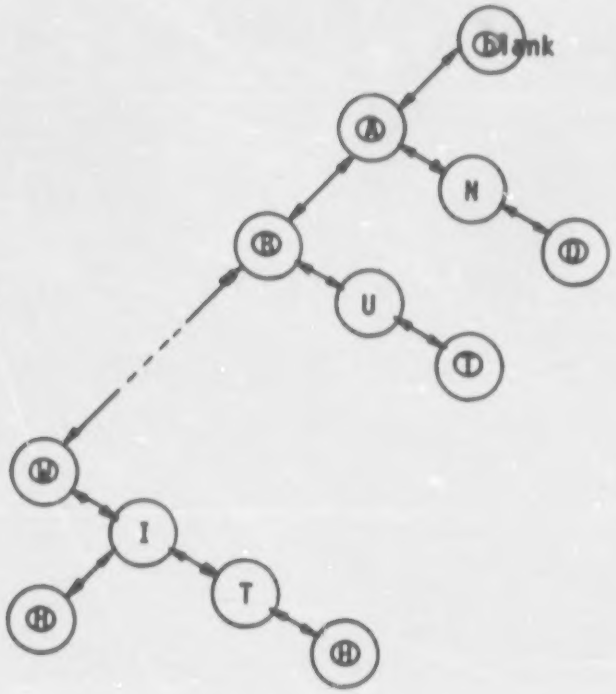


FIGURE 1.

Braille equivalents and decision information would be stored in the double-circled cells labelled "blank", "A", "D", "B", "T", "W", and both "H"s, all of which correspond to valid braille equivalents.

In the course of scanning a word to be translated, one might find the word "with". One would then start down the dictionary list looking for "W", branching to the "right" when agreement was found and to the "left" if no agreement is found at each circle. In this way one would proceed past "blank", "A", "B"...down to "W". At this point agreement is found, so the next letter "I" is looked for, going to the "right". It is found, so the

"T" and then "H" are looked for and found, again progressing to the "right". At the final position "H" one would check for a braille equivalent and decision information. If this were not found, one would retrace his steps "upwards" to "T", "I", and ultimately to "W" until a braille equivalent and decision information are found in a cell. The braille equivalent is written, and the process is repeated wtih the rest of the word.

The present program, now working, "lops off" characters from the left. There is some possibility that accuracy in translation would be enhanced if one were to work from right to left rather than left to right, or that a combination of both searching techniques would be advantageous. This we hope to investigate further.

Another example: At another point in the translation one might encounter the word "whence". In this case one would find the "W" as before. However, on proceeding to the "right", the next letter encountered is "I". One is searching for "H" so one branches to the "left" from the "I". There "H" is found and no pointers are found to any further entries. In this case decision entries and braille equivalents are found with the "H" so the braille equivalent of "WH" is then obtained, and the search for "ENCE" is instituted from the top of the tree structure as before.

This dictionary structure contains punctuation marks, special symbols, groups of characters and words for which braille contractions exist, and the numerals 0-9. As translator development proceeds, the dictionary will also contain entire words which cannot be properly translated otherwise. By entering our dictionary as data in punched card form at the time of the translation run, it is felt that the flexibility of the dictionary and therefore the ease and simplicity of the use of the Argonne translation system is enhanced, a capability not present in some other existing programs.

D. Retranslation Facility

A separate module has been incorporated in the basic translation package. This takes the digitized braille output and retranslates it to inkprint and a representation of braille output -- utilizing the period to signify a raised dot -- for the purposes of obtaining statistical information about the frequency of usage of the various contractions and symbols used in braille and for proof-reading purposes. Contractions are indicated by vertical placement of the letters of the contraction under the braille output. This output is for the benefit of the sighted proofreader. In a later version of the program, braille produced on the line printer in the form of raised dots is planned for the benefit of blind readers. No attempt is made to divide words at the end of lines because of the nature of the system under consideration. In the Argonne Braille Machine a continuous stream of output is required, and words therefore are never divided.

The retranslation portion of the program has been made a separate module so that it can be easily omitted if it is not desired, and so that the translation portion of the program can be kept as "clean" as possible of details extraneous to the translation problem. This has been an aid in debugging and has the further advantage that the statistical considerations are most easily handled in the retranslation step.

The input to the retranslation step consists of a string of 8 binary digits (1's and 0's), the first 6 of which represent the presence or absence of braille dots. Each group of 6 digits is considered to be a binary number (labelled "SUB") and, using a facility of PL/1, is used as a subscript in an array of 64 statement labels (called "LABELS"). The PL/1 statement "go to labels (sub)" then sends the execution process to the correct section of the program. At this point the translation of the braille character is accomplished and the program continued to the point where the braille cell is assembled. If appropriate, an entire line of braille representations and inkprint equivalents is printed out at this time. Advantage has been taken of decision table techniques to determine the ultimate unique translation of a group of 1 or more braille equivalents.

At the time the translation is accomplished, the appropriate counter is incremented to indicate the use of a particular contraction. At the end of the retranslation process the value of each counter is printed out along with the identification of the contraction for which it is used.

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PROSPECTS FOR UTILIZATION OF COMPOSITOR'S TAPE IN THE PRODUCTION OF BRAILLE - Grete Grunwald

A Revolution in Braille Publishing Procedures?

A goal for many workers for the blind has been to make braille as abundantly available to the blind as inkprint is to the seeing.(1) The obvious main obstacle in achieving this goal is the relatively small number of copies required in braille, and the corresponding high cost per copy.

Could not commercial printing give a hand? For instance, "...A text that is automatically revisible and transformable along planned lines would allow regional and minority publishing."(2)

Compositor's tapes (that is, tapes prepared for automated typesetting) contain text in automatically revisible and transformable form. Such tapes, therefore, seem to be useful for minority publishing (as would be any text which is machine-readable). The problem is to find sources for such material.

Is there a Braille Revolution coming, based on compositor's tape? That would depend on whether there is enough tape available (especially of straight matter); that means enough to assure a braille publisher fast and convenient access to a wide choice of titles and to keep the overhead from spiraling as a consequence of information-hunting.

Furthermore, not every compositor's tape is equally suitable for transformation; Rice, in the quote above, rightly stresses transformation along planned lines; he lists, for instance, careful indexing and correct coding as well as "flagging" of points at which decisions may be necessary.

In order to weigh the chances for finding a firm base for braille in materials used primarily for commercial printing and publishing, it is necessary to understand what is involved up to the stages of printing and publishing literature.

In 1964 approximately 28,000 titles were published in inkprint in the U.S.A.(3). Editing and printing is the combined business of the publishing and printing industry.

This huge industry is in great pains through a challenge which started some 30 years ago, when rapid advances in printing techniques occurred. Mechanization, automation and specialization, together with entirely new techniques, and finally, within the last decade or so, the use of computers in composing rooms caused revolutionary changes. Individual firms adjusted, converted; new mutations evolved. Traditions were shaken. (These statements are derived from the body of quotations in the appendix.)

One of the most unsettling events in this whole uproar was undoubtedly the introduction of electronic data processing. Here are a few corresponding news items:

> "...There are approximately 100 to 125 commercial printers, publishers and trade typesetters utilizing the computer for composition functions."(4) October 1966.
>
> "...Fantastic growth of computerized typesetting installations: from 77 in 30 countries in 1964 to 1,093 worldwide in 1969."(5)
>
> "...installations jumped 54% in 1967 and 33% in 1969; in U.S.A. about 900 composition typesetting operations."(6)
>
> "...The first 20 RCA Video Comp., which went on line between 1967 and 1969 are capable in themselves of setting all of the books published in the U.S.A. during the full year."(7)
>
> "...There are now well over 1,000 computers being used for typesetting."(8) January 1970.

On the other side of the coin there has been much publicity and many unsupported claims. Many references to this kind of "information" are to be found in the appendix. Lamparter says for example: "...Superficial review articles are appearing with increasing frequency in both the business publications and in the popular press. Unfortunately this outpouring of information has too often been incomplete and oversimplified."(9)

Regarding the peculiar aspects of braille publishing, consider that traditionally manuscripts are submitted to the publishing industry to print books, and eventually some of these books get transcribed into braille -- relatively inefficient and at high cost. Lately, a few titles were keyboarded for computer processing of the text into Braille Grade II. The advantage of this method is that any of the many trained keyboarders can handle English without having to know the rules of Braille Grade II; these rules can be supplied by a computer later. However, the cost for this work was found to be excessive for the production of a relatively small number of braille copies per titles.

So, it was natural that people concerned with publishing braille got excited about the possibility of using existing tapes -- produced by large commerical printers for their own composition -- to generate braille.

The idea was to obtain mpositor's tapes inexpensively after they have been used for commercial printing, where the commercial printer would absorb the high cost of keyboarding -- certainly an intriguing thought.

This thought has been pursued for many years and by different people. However, as far as we know, only in one place has compositor's tape been used to produce braille on a continuing basis, and even this operation has again dropped most of the automatic data processing in its operation.(10)

Why, one asks, has the idea of "generating braille from compositor's tape" not been more successful?

In looking for answers and in order to understand the attitudes of professionals in the field of printing and publishing in the U.S.A. as well as abroad, we searched numerous publications from government, industry and information centers (see Appendix); we asked for response to a questionnaire (sample in Appendix, p. III-I-68); we visited and interviewed directly a number of experts.

As a result we found much that is disputed, but general trends seem to emerge.

We give here a selection of brief direct quotations taken from publications. (For more detailed and extensive listings the reader is referred to the appendix.)

..."We know that straight keyboarding of copy, regardless of the high speed system following, is handcuffed to manual operator speed."

The Honorable J. L. Harrison, p. III-I-30

..."working to bring about a solution to the conflicting needs for speed in composition and desirable printing practice."

J. F. Haley, p. III-I-31

..."Opinion regarding markets and production technology...based on few or no data."

H. C. Lamparter, p. III-I-33

..."The application of computer controlled ultra high-speed typesetting to book production -- principally textbooks -- is an area of some controversy."

..."the high powered gear saves nothing on keyboarding or proofreading which, with page make-up, is at least 80% per page composition cost in book work."

..."to a machine cost of $6 per page one adds at least $8 - $9 for keyboarding and proofing."

..."page rate on a trade book goes from $6.50 - $8 via conventional methods to at least $12 - $15 on an ultra high-speed typesetter."

..."In-house data creation at the publishers-- its immediate advantages lie in control of data creation and production schedule."

Sedgwick, p. III-I-43,III-I-44

..."Complete automation of typesetting will probably remain a technologist's dream."

..."Any discussion of automatic typesetting seems to flounder at the input stage."

..."typesetting demands a preponderance of data preparation and relatively little computer processing."

..."a consensus of published experience suggests that on a single column news (newspaper) the improvement in productivity will be about 15 to 25 percent. A book printer employing wider measures should not expect much more than 7 to 10 percent."

..."40 to 50% of caseroom time (goes for)...corrections, page make up (takes) a good proportion of the remainder."

Wallis, p. III-I-48,III-I-50

..."Computerized composition has not yet made much of a dent in traditional typesetting of 'straight matter' such as book work."

..."What is required of the publishing industry is standarization of format."

Rice, p. III-I-57

..."Computer typesetting in U.K.: ...already a multiplicity of equipment, which pose problems to the printer who feels he ought to be in."

..."In most instances the basic reason has been (the hope) to reduce costs."

..."Most of the schemes have involved the retraining of linotype operators, many of whom have not yet reached their potential speed on the new keyboard."

Pira, p. III-I-63,III-I-64

Results from the inquiry with our special questionnaire were as follows:

Question 1: Tape used: material(s), format(s), code(s).

Question 2: Systems used.

It is particularly striking -- and it has, of course, far-reaching consequences -- that each of the respondents uses different formats and systems. We therefore think it important enough to quote the corresponding answers verbatim.

1 6 channel punched paper, TTB code.
7 track 556 B.P.I. with BCD blocked in 1000.
as character records.

2 H 1200, 65K, 6 tapes + 2 discs.

1 perfected from 8 level paper tape by Frieden 2501 keyboards
9 track 800 BPI
variable records.

2 RCA Spectra 70-35 with Videocomp 822 using page 1 software.

1 6 channel TTS paper
special keyboard layout
unjustified

2 Hot metal, Electron mixer, automated via Line-a-Sec. for line measurement.

1 800 BPI mag. tape, EBCDIC code.
9 track

2 IBM 360/30 or 360/40 with ABC composition system.

1 6 level TTS paper tape and MT/ST (extended keyboard-k Pak). We produce tape for composition and computer manipulation.

2 Photon 713-20, IBM MT/SC, AM725, Electrons, Harris fototronic CRT, IBM CRT (Alphanumeric).

1 1/2" Magnetic tape, EBCDIC code
7 track 556 B.P.I.

2 Originally designed/implemented SIGMA 2 equipment.

1 6 channel punched paper, converted to 1/2" magnetic tape
7 track film

2 Videocomp RCAbase system, Spector 70 computer; Poole Brothers' RCA system, Spector 70-35 computer.

Question 3: How clean are tapes? What is the error rate? Are all corrections carried back to data base?
3a: Are tapes complete?

Especially disturbing is the variety of responses to the items "error rate" and "clean-up" carried out on tape. We give therefore again a complete listing.

3 1 error per 1000 characters

3a We correct data after it has passed "raw" data stage. (clean?)

3 100% clean

3a Yes, 100% carried back; tapes are complete except for front and some back matter.

3 95% clean

3a Corrections are not carried back to data base; tapes incomplete.

3 over 90% correct; (clean)

3a Yes, corrections are--at present--brought back to data base; tapes complete but may be on multi-reels.

3 -----(no answer)

3a Yes, (back to data base); tapes complete.

3 -----(no answer)

3a Yes; all corrected; complete in galley form.

3 All paper, as well as magnetic tapes are corrected; "clean".

3a -----(not answered).

Question 4a: Reformat to specified code?

Some houses can and are willing to do so. Others could do this on magnetic tape only -- or, "Have no present program for this, but it could be done."

4b: Price per title? (reformatting to specified code)

"Would depend on amount of change. MT/ST cost per hour is $7.85." "Estimated cost on first basis $1,000"; others say: "program and machine time $200."

Question 5: How long are tapes kept after completion?

"Hold as directed by publisher, or (else) not kept at all."

"Some titles kept not at all, others 4 to 5 years, depending on subject."

"One year, thereafter asking for storage charge."

"If not otherwise specified, will be erased and reused as soon as safely past photographic plate making."

Question 6: Release of tapes (or copies) for braille production:

Only one respondent replied: "free of charge." Other responses vary from $15 to $200; or "Free--if costs for eliminating machine commands, etc. are recovered."

Question 7: Scope--titles per year--produced with compositor's tape.

	(Range of estimates by respondents).
Straight English	From 20 to 500 (average 325)
Scient. & College	From 40 to 150 (average 83)
Element. & High Sch.	From 6 to 50 (average 18)

Question 8: Projected usage of compositor's tape by 1980.

Straight English	From 50 to 100% (average 78%)
Scient. & College	From 25 to 80% (average 64%)
Element. & High Sch.	From 75 to 80% (average 77%)(11)

For first-hand information we have visited or contacted the following publishing houses, printing plants and computer composition companies:

Bantam Books, Inc., CompuScan. Inc., Computer Typesetting, "Black Dot", Dell Publishing Co., R. Donnelly & Sons, Follett Publishing Co., Hadden, W.F. Hall Printing Co., MacGraw Hill Book Co., The McMillan Company, Poole Bros., Prentice Hall, Rand MacNally & Company, Random House, Roccappi Computerized Composition, "Tape Type", Vermont Photo-Tape serv., Westcott & Thompson, and Western Publishing Co.

The Goss Co. in Chicago kindly allowed me to use their excellent library.

The interviews largely reinforced information obtained through the literature research and the questionnaires. The following observations are worth mentioning separately:

a. The research director of a large publisher said: "We use data systems' Keymatic Console (somewhat like MTST, but directly computer compatible output). One should do much clean up at this stage (before composition); keyboarding accounts for approximately 45% of total composition cost."(12)

Advantages of automatic composition are: "The resulting print page is superior to manual composition; furthermore, there is fast turnaround. --Automated composition is mostly attractive for material which is subject to change; but better product and reduction of printing cost (because of optimal page utilization) make straight matter also competitive." -- "newspapers are switching to offset; this causes the hot metal technology to wither, because of loss of their biggest market."

b. A compositor: ..."expects to see hot metal technique to disappear in a few years, to be replaced by optical (film) composition. But tape availability is nevertheless not assured: Only ∿ 5% of the text are complete, fully corrected tapes and are retained (for future printing, etc.). Most tapes are kept only a short time." And we may add: often as a jumble of short sections of paper tape which are thrown in cartons without organization. Many corrections are made by hand on the final (film) copy and therefore never get back to the tape!

"Tapes are not necessarily complete; they may for one book be made by several compositors; sections of one book may be done directly in hot metal, whereas others are done with tape, etc. Many different systems are in use and publishers use different codes, thus making some available tapes incompatible with others."

c. A very large publisher told us that: "straight matter (novels) is usually printed only once";

that: "They use MTST and convert its output into computer readable form".

"...perhaps as much as half of our compositions for books of general interest are presently being composed from tape".

(however) ..."At the present time, we have very little material available on which a 'perfect' tape exists."

..."Unfortunately, most if not all of the conventional composing systems and the earlier photo-composing systems do not result in a correct 'perfect' tape. In the case of all of these systems, the keyboard tape is used to create galley proofs of hot-metal type, or photographically-created type images. All identified errors are then corrected directly in metal type or by stripping corrected copy on the film output. It is only in the case of the more advanced computer composition systems that a 'perfect' tape, embodying all of the corrections, is created."

"permission to use a compositor's tape would not only have to be obtained from the publisher but also from the author."

d. The president of a large compositor: he confirms that ..."at present composition of 'straight English text' is rarely produced by computer because so far it is more expensive." (Do you expect that to change?) "Definitely!" (How will it become more competitive?) "Prices will come down with volume." (You mean if a publisher contracts with you for 100 book titles instead of 10, you would lower your price drastically?) "Absolutely!" (When do you expect that automated composition will take 100% of this (straight matter) market?) "Never; about 50% in 10 years." "As far as the next six months are concerned it is difficult to predict what we may produce."

Conclusions

At the beginning of this paper we asked the question whether braille production can be revolutionized by utilization of compositor's tape.

Techniques for producing braille in this way do work. But, what does this do to enhance--in Professor Mann's words--the availability of braille? Unfortunately, the answer to this question is "at present next to nothing."

Relatively few titles get on tape;

relatively few of them get on tape completely;

not many of these are "clean" of errors;

and not all of these are preserved for any length of time after having served in the printing operation;

and the final residue which is useful for the braille producer is formatted in numerous, different and noncompatible ways.

So, the braille producer has to pick out a few grains of wheat from what is tons of chaff to him. Furthermore, offerings of tapes by the industry are concentrated in a few special fields, such as textbooks, dictionaries, etc., as a consequence of economic factors. At least this is so at present, and it seems likely that these factors will continue to operate in the foreseeable future.

The resulting effort in finding usable material is bound to discourage the braille producer.

Furthermore, because of the low volume of braille demand the braille producer is hardly ever specialized with respect to type of literature; thus, even if compositor's tape were relatively more abundant for some limited part of his production, he would not seem to be much better off: To take advantage of this opportunity would make life for him more complex and difficult and he may well wonder whether the results are worth all that much.

What can be said about the future?

Generally our search has not identified causes for drastic change from the present situation; some agreement seems to exist that more tapes and better tapes will gradually become more available--but hardly anything like complete conversion is predicted by the experts. As a matter of fact there can be seen some factors at work which may counteract such a development, for instance, the proliferation of competing and not compatible equipment. It would seem, then, that the future does not hold any revolutionary promise for compositor's tape utilization by braille producers.

If and when much--or all?--information (including novels, poetry, etc.) will be stored in machines, one would of course not have to worry about sources for machine readable input any more; braille would simply become one of many possible outputs of "the machine," and complete availability would result.

If and when......

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(1) Robert W. Mann, "Enhancing the Availability of Braille." American Foundation for the Blind, 1963, p. 413.

(2) Stanley Rice, "What's the Future of 'Straight Matter'?" Appendix p. III-I-57.

(3) The World Almanac and Book of Facts. New York World Telegram and Sun, 1966, p. 512.

(4) William Lamparter, Economist at "Battelle" (worldwide 'contract' research), "Impact of Electronic Composition on Commercial Printing and Appendix, p. III-I-34.

(5) Spencer A. Tucker, Consultant Director, Composition Information Service, Los Angeles. Printing Magazine, March 1970, p. 37.

(6) Ibid.

(7) Ibid.

(8) McLean Hunter, Computer Information Center, Inc., Los Angeles, "Survey of Computerized Typesetting," British Printer, January 1970, p.16.

(9) William Lamparter. Appendix p. III-I-34.

(10) The joint venture of the University of Muenster, with a German magazine publisher and a social agency for the blind, does issue regularly braille versions of several magazines.

(11) Several of the respondents stressed the speculative nature of their own estimates. Furthermore, the most optimistic estimates came in several cases from respondents who had only recently started automated typesetting. In the light of the literature quoted, it is our opinion that the estimates given here, especially for straight matter, are far too optimistic.

(12) Editors' intervention concerns itself mostly with formalism (not much with meaning)--thus unimportant for braille use even if missing in available tape.

APPENDIX

to

PROSPECTS FOR UTILIZATION OF COMPOSITOR'S TAPE IN THE PRODUCTION OF BRAILLE

U. S. Department of Commerce
National Bureau of Standards

Keywords: Automatic Type Composition
Computerized Type Setting
Graphic Arts
Photo Composition
Printing and Publication*

by: Mary E. Stevens
and John L. Little

About the 12th Century, B.C., the Chinese first introduced wooden blocks of movable type. . . .

Johannes Gutenberg, a German stonemason, 1440, demonstrated the practical use of movable metal type . . . which led to modern printing. . . .

Production of printed pages thus dates back at least 500 years. Gradual mechanization of typesetting operations occurred during the following four centuries, including the introduction of keyboards for type selection and the development of devices for the automatic sorting of used type slugs.

The use of machines and of mechanizable processes to improve the utilization of scientific and technical information has a first and obvious area of application in the preparation of copies of text and tabular data for distribution or publication.

Mechanized printing began with the invention of movable type. The
first scientific journal began publication in 1665; the first abstract 1665
journal appeared in 1807. 1807

An interesting early example of possible mechanical processing for composition of revised and updated bibliographic listings was reported by Charles G. Jewett to a convention of librarians held in New York in

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*Editor's note: For the purpose of the paper at hand, the above keyword-subjects are put together chronologically and also drastically condensed.

1853. "Every book's title, distinct edition, and author is stereotyped upon a plate, mounted on a block in alphabetical order of title. . . to be able readily to insert additional titles and then reprint the whole catalogue." 1853

So Clapp reports, "a simple catalogue, printed 1854, for the Library of Congress from these plates still exists." The plates warped in storage; Jewett was betrayed by the imperfect technology of the time. 1854

Not until nearly a century later, with both manual and sequential card camera shingling techniques, were some of these advantages realized.

In the late 19th century, a great leap forward was made in typographic composition. . . . linotype by Mergenthaler and Monotype by Lanston. The linotype, first used by the New York Herald Tribune in the late 1800's, is a keyboard operated machine which casts a hot metal slug for each complete line of type. The monotype equipment involves two separate machines. A large keyboard used to operate a paper tape perforator. This perforated paper then controls a hot metal type slug caster. late 1800's

During the last few decades, and particularly during the most recent decade, there has been a notable increase in the availability of mechanical aids in composition operations.

Eastman Kodak was active in the field of electronic character generation in the middle to late 1940's, leading to demonstrations of DACOM equipment in the early 1950's. As early as 1948, this company filed patent applications with respect to means for displaying characters on the face of cathode ray tube. . . . These patents were then cross-licensed to RCA, to IBM, and to at least one British organization. late 1940's

The first patent applications for what is now known as the Photon (the Lumitype in France) were filed in 1945.(1) 1945

In 1946, Corrado reports, "Mergenthaler was experimenting with a cathode ray tube, closed loop, television system to produce type on film." 1946

Reporting in 1959 on then current progress in photocomposition, Winkler said: "The Fotosetter, developed in 1947 by the Intertype Corporation, was the first commercially available phototypesetting machine. The Photon, of Photon, Inc., was the second phototypesetter placed on the market. In succession, the Monophoto of the Lanston Monotype Company and the Linofilm machine of the Mergenthaler Linotype Company were introduced. The American Type Founders, Inc., has recently made the ATF Typesetter available." 1947

Winkler also describes the Research & Engineering Council of the Graphic Arts Industry, Inc., which was started informally in 1948, and formally incorporated in 1950.(2) 1950

Editor's comment

The year 1954, however, marks the official date of disclosure of the first comprehensive approach to the use of modern machine techniques to typographic quality composition generally involving both computer processing and automatically controlled composition devices (Bafour, 1965).

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(1) Since that time, the inventors, Messrs. Higonnet and Moyroud, have taken out over 40 U.S. patents as well as numerous foreign patents on various inventions in the field of photo-composition. . . .

(2) Further impetus was given to this type of photocomposition technology by the Graphic Arts Research Foundation, Inc., from about 1948-1949 onward. First commercial computer (UNIVAC) delivered to Bureau of Census.

As Duncan reports: "The proposal to apply the power of modern digital computers to text processing originated with Bafour, Blanchard, and Raymond. Their patent application was made in France in March 1954 and must have been preceded by a great deal of work. Their system as originally conceived embodied a special-purpose tape-typewriter keyboard (at least one prototype was built by Barriquand and Marre) with additional keys for function codes and means for producing correction tapes and merging them before processing in a special-purpose computer, details of which were also specified in the patent. . . They clearly envisaged that the output would control both automatically operated linecasters and other more advanced photo-composing machines." 1954

At Mergenthaler. . . work was begun on the photocomposer Linofilm, the first prototype production model having been tested in the period 1955-1956.(3) 1955-1956

The year 1958 saw the first publicly available production of KWIC (Key Word-in-Context) indexes, those for the Preprints of the International Conference on Scientific Information (machine-produced but not of typographic quality), the initiation of projects to explore the potentialities of photo-composition at the American Chemical Society and, in France, "experiments. . . carried out using a computer of the Societe d'Electronique et d'Automatisme. The output tapes were fed into the Intertype casters of the Imprimere Nationale, equipped with Fairchild readers and control units."

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(3) Experimenting started 1946.

Duncan comments with respect to the latter experiments as follows: "The tragedy is that after the brilliant demonstration of November 1958, the French Syndicate did nothing to exploit the system."(4) 1958

The lead thus lost in France was to be picked up both in the United States and in Great Britain in the period 1959-1962 with respect to photo-composition equipment as such and also with respect to computer control of various compositor functions. Hoffman, in a 1959 survey of composing room materials and machines, reported as follows: 1959

> Photography. . . is an industrial phenomenon creating a major upheaval in the graphic arts industry. . . . Electronic control of the photographic composing process is already here. . . While not at present available commercially, machines such as Monophoto and ATF Typesetter indicate that photographic composition in justified lines of straight matter can be expected soon from several machines.

From 1959 to 1961, an investigation and study of "graphic-semantic" composing techniques was conducted by the Syracuse University Research Institute for the Rome Air Development Center (Buch et al., 1961).

IBM, which was developing the concurrent machine translation efforts, subsequently demonstrated output of text via computer program and Linofilm.

In 1960, as a result of the American Chemical Society's graphic arts research program, production of the quarterly Journal of Chemical and Engineering Data by photocomposition techniques was begun, utilizing 1960 manually keyboarded Photon equipment. In the project summary prepared for Current Research and Development in Scientific Documentation, No. 7 (for November 1960), it is stated that results with respect to the economics of the process were not conclusive as of that time, but "there are indications that the process is at the very least competitive with hot metal costs."

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(4) The latest information from France is that a large computer firm (SCF) and the typewriter firm of Japy together with Barriquand and Marre are about to carry on the work, having lost a lead of six to ten years.

A two-year program for the investigation of the use of photocomposition techniques in the setting of mathematical text, such as the journal Mathematical Reviews, was initiated at the American Mathematical Society in January 1962. 1962

In 1962, the Joint Committee on Printing of the U.S. Congress initiated action which led to the establishment of the Federal Electronic Printing Committee, to the setting up of the post of Electronic Printing Officer at the U.S. Government Printing Office, and eventually to the ordering of Linotron equipment for the Government Printing Office. (Mergenthaler had already entered into a contractual arrangement with the the Columbia Broadcasting System Laboratories for cooperation in the graphic arts field, resulting in the eventual Linotron design.)

By this time, also, the Russian All-Union Institute for Scientific Information (VINITI) was evidencing specific interest in computers and high speed composition techniques. Thus, in 1962, Mikhailov reported "development of new highly-productive printing equipment including photosetting and photo-engraving machines, high-speed mono- and lino-types, composing typewriters," and the like.

In July 1962, occurred what is probably the first finished book of tables involving the combination of computer processing and automatically controlled photocomposition, NBS Monograph 53, Experimental Transition Probabilities for Spectral Lines of Seventy Elements (Corliss and Bozman, 1963). The introduction to these computer-generated tables of values states in part:

> At the beginning of the preparation of this table it was realized that equipment was available which would permit essentially automatic preparation of the finished book. It was therefore decided to attempt to produce this publication by completely automatic methods. An electronic computer could be used for the computation; then the magnetic tape output from the computer could be used to operate an automatic phototypesetting machine which would produce film ready for making the printing plates.

Also occurring in 1962 were the initiation of the automatic composition program at the University of Newcastle, preliminary demonstrations of typesetting by Computaprint Ltd. for the British Institute of Printing and delivery of the prototype Linasec to the Alden Press. The ROCAPPI (Research on Computer Applications in the Printing and Publishing Industry) organization initiated a program for automatic control of hot metal linecasters in October 1962 and went into limited production in January 1963.

The year 1963 may be said to mark the major beginnings of automatic composition. As reported in "The Penrose Survey" for 1964:

> A number of firms had installed the Intertype Fotosetter and the Monotype Corporation's Monophoto, but the more elaborate machines still awaited major acceptance. This came in 1963 when a number of

> installations of the Linofilm and Photon-Lumitype were made. . . the decline printing from movable type can definitely be associated with 1963. . . 1963 also saw the development and acceptance of setting by computer.(5)

In October 1963, the registrants at the annual meeting of the American Documentation Institute received two volumes of short technical articles, claimed to be the first of its kind to be typeset by computer.

Finally, in August 1964, appeared the first issue of the national Library of Medicine's Index Medicus to be computer-compiled and automatically typeset at high speed direclty from magnetic tape. 1964

Meanwhile, other news publishing organizations had moved ahead with the installation both of photocomposers and of computer control systems to operate either hot metal casting or photocomposition equipment. Thus, by 1964, it could be reported that "a recently conducted survey. . . revealed more than 75 installations involving the computing equipment of some ten different manufacturers. . ."

Additional evidence of the rapidly emerging state of the art is that of labor relation reactions. In July 1964, union printers went on strike in Toronto.

Two distinct technical advances in type composition have thus emerged over the past two decades, and especially in the past two years: first, the substitution of photocomposition and/or cathode ray tube character generation coupled with photographic, xerographic, thermographic and other copying processes, and secondly, the use of computer techniques or devices up to and including general purpose high speed digital computers to control either hot metal casting or film-set printing processes. In addition, both types of technical development may be and have been combined in a single application.

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(5) (From pages 66-67) Book composition advantages are at least on the horizon. . . Alden Press:. . . "We look forward to high volume production of quality type at reduced costs on faster production schedule."
In the same year, 1963, Westerham Press Ltd., England, began a research program for computerized typesetting. At Rocappi book composition developments are under way on a service bureau basis.
Blundell claims: "A special advantage of computers for books is that type only has to be set once. . . ."

A third technological development, that of tie-in to communication networks, has come to practical fruition, from 1963 onward, for stock market exchange quotation and newspaper special edition applications at remote locations, such as the RCA-TTS Dow Jones system, the Wall Street Journal system, and the New York Times system.

Closely related to the newly emerging applications of book composition is the notion of the service bureau or center which will do automatic typographic quality composition on input from a variety of sources. Already, "service center developmental activities are fermenting and materializing in many sections of the country." Examples include ROCAPPI (Research On Computer Applications in the Printing and Publishing Industries) both in cooperation with other Philadelphia firms (W. B. Saunders Saunders and Computer Composition, Inc.) and in England (Hazell Sun Ltd.), Keydata Corporation (Boston), and others.

Developments involving linkages with communication networks will probably encourage the growth of these and other centers. Duncan reported at the 1964 Computer Typesetting Conference that

> . . . data relay equipment over wired networks. . . is at last available. . . of adequate performance and at a reasonably economic cost. We can now expect to see the expansion of service activities and they may eventually be able to provide computer typesetting programs for their customers and an off-peak service at acceptable rates.

A special case of service center operation involving dissemination of news and current trade development information to its subscribers is Composition Information Services, Los Angeles, which issues at regular intervals the CIS Newsletter. In the August 1965 issue, for example, coverage was provided to the impact of potential automation and implied re-education as viewed by the 46th International Association of Printing House Craftsmen, news of a grant for continuation of Newcastle projects for computerized typesetting, and reporting of phototypesetting equipment at an international exhibition in Paris, including Hell, K. S. Paul (P&M) Filmsetter, CAE, Monotype, Photon, Mergenthaler, and others. 1965

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"ELECTRONIC COMPOSITION IN PRINTING"

Proceedings of a Symposium
National Bureau of Standards
June 15 and 16, 1967

	"INTRODUCTORY REMARKS"	Ethel C. Marden
	Session I	
[from]	Session II - Government Policy. . . .	
	"A NEW LOOK AT THE G. P. O."	The Hon. J. L. Harrison
	"PRESENT AND PROJECTED POLICIES AT THE J. C. P."	J. F. Haley
[from]	Session III - Non-Government Applications and Research	
	"THE IMPACT OF ELECTRONIC COMPOSITION ON COMMERCIAL PRINTING AND PUBLISHING"	W. C. Lamparter
[from]	Session IV - Government Applications	
	"A BRIEF OVERVIEW"	S. N. Alexander
	"ELECTRONIC COMPOSING SYSTEM APPLICATIONS"	J. J. Boyle
	"COMMENTS"	Mary Elizabeth Stevens

Center for Computer Sciences and Technology
National Bureau of Standards

INTRODUCTORY REMARKS

by Ethel C. Marden

. . . . electronic computers now affect a whole spectrum of areas; one of the newer of these is printing.

It is a common observation that a change of an order of magnitude -- that is to say, by a factor of 10 -- in a technology produces fundamentally new effects. . . . For example modern jet planes -- about one order of magnitude. Another example is the automobile. But these changes have occurred over a period of 50 to 60 years. By contrast, the first stored-program computer was completed only 17 years ago. Yet such computers have increased the speed of computation by more than 7 orders of magnitude over hand computation. . . . yet this change has come about in a much shorter period of time than corresponding changes in other areas.

change of an order of magnitude (factor of 10) produces fundamentally new effects. . . modern jet planes about one order of magnitude in a period of 50 to 60 years. . . program computers increased speed of computation by more than 7 orders of magnitude in a period of 17 years

Initially some of the effects of the new technology were ignored. Computers were built to compute, so we used them for that purpose; but we still did things in pretty much the same way -- we just did them on a larger scale and we did them faster. In the last few years we have begun to explore many ways in which this technology can be exploited: . . . , ... , . . . and in electronic composition for printing.

Computers were built to compute, so we used them for that purpose; but we did things pretty much the same way -- we just did them on a larger scale and we did them faster.

The Federal Government spends more than 3 billion dollars a year in computer rental and purchase and in the application of information processing on computers. When this level of spending is reached, cost effectiveness becomes a very significant factor in operation. Cost effectiveness criteria must be applied not only to the cost of initiating a particular operation but also to the costs of error detection and correction in subsequent information processing operations. In data handling operations these latter costs usually represent the major part of the total expense of the operation. In a multistage information processing activity it is desirable to manage when possible with a single input and to generate subsequent ones. Cost effectiveness becomes significant in measuring different ways of handling multistage operations, particularly when manual handling is involved in any portion of the processing. It is easy to calculate overt costs but very difficult to put a dollar value on the intangible cost of errors. This cost is a significant feature in many operations, but particularly in report and manuscript preparation. By means of electronic composition, it should be possible to reduce by a measurable amount the tangible costs of publication and to diminish dramatically those intangible costs associated with error elimination.

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The first stored-program computer in this country, the SEAC, was built by NBS in 1950. In 1965, the Brooks Bill (Public Law 89-306) gave NBS additional responsibilities for standards in both hardware and software, for rendering consultation and advice to other Government agencies in the use of computers, and for the innovation and extension of techniques for their use.

first stored-program computer in this country (SEAC) was built in 1950 (1965 Brooks Bill Law 89-306)

Here an important area is the application of electronic techniques to composition in printing. In this connection we are very much concerned with the development of techniques to expedite the handling of textual information. It is therefore eminently suitable for the Bureau to sponsor this Symposium on Electronic Composition in Printing.

I should not like to predict what changes we shall see in the computer technology or in electronic composition in the next 15 years, or the next 10 years, or even the next 5. But of one thing I can assure you: changes -- and dramatic changes -- there will be.

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. . . in the computer technology or in electronic composition. . . I can assure you: changes -- and dramatic changes -- there will be

A NEW LOOK AT THE GOVERNMENT PRINTING OFFICE

by The Hon. James L. Harrison
Public Printer of the U. S.

. . . Last year the Government Printing Office. . set more than three billion ems of composition. . . Today, slightly over half of our annual printing volume is procured from commerical printing houses throughout the United States. We have more than 2200 firms on our list of active suppliers. . . . In 1960, our business volume was just below $100 million -- this year we expect it to reach $210 million. In 1960, commercial printers did 40 percent of the total and this year will do 55 percent. .With virtually the same work force . . . . we are meeting a ballooning Federal requirement for printing. . . .

We have more than 2200 firms on our list of active suppliers.
our business volume was (1960) just below $100 million -- this year we expect $210 million [1967]
commercial printers did 40%; this year will do 55%

Two innovations, as far as the Government Printing Office is concerned, loom large in the assessment of our future plans -- offset and electronic composition. Today, we are producing more impressions by offset than letterpress. . . .

Today we are producing more impressions by offset than letterpress.

While commercial experts were spreading the doctrine of long runs for profit, our offset division demonstrated the soundness of producing even modest runs on web equipment.

This Symposium is chiefly taking place in order to review progress in electronic composition in printing, let me turn to the Government Printing Office's activities in this area. . . .

In 1962, the Joint Committee on Printing. . . . pushed us out into the forbidding and relatively uncharted sea of computer-oriented composition.*

But back four or five years ago when the work of the Committee gave substance to our estimates that 20 percent of all Government Printing was being composed entirely -- or in part -- on EDP equipment, we realized that a temporary or interim solution was needed -- and quickly. So the Government Printing Office seized the initiative and installed a system which we felt would provide much-needed experience, information, and training in this field. . . . we were fixing our sights on the ultimate answers to our composing problems.

we are now [June 1967]
expecting delivery of the Linotron system in a few weeks**

we were fixing our sights on the ultimate answer to our composing problems

This first essay into computer composition took the form of two Linofilm keyboards, a Linofilm photo unit, prototype-paper-to and magnetic-to-paper tape converters, three Justowriter perforators, and three electron tape-operated slug casting machines. Two IBM 1401 computers were already in service in our accounts division.

We now have five units and the old 1401's have been replaced with an IBM 360/40 and a 360/50. . . .

Tomorrow you will be treated to a "nuts and bolts" presentation by Jack Boyle. . . .

I want to emphasize that our electronic printing policy is a down-to-earth effort to bring you savings in printing costs. . . Our electronic composition posture is first rate.

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* Our exploratory group, . . . the Federal Electronic Printing Committee's. . . findings formed the basis on which the Government Printing Office has acted, and were instrumental in moving us to the forefront in the search for a suitable electronic composition system.

** We are now on the threshold of realization -- expecting delivery of the highly sophisti-

. . . **One thing experience has taught us is that we have just scratched the surface in this field. The state of the art,** despite today's complex and sophisticated systems, is in its adolescence. We know, for example, that straight keyboarding of copy, regardless of the high-speed systems following, is handcuffed to manual operator speeds. While we are learning ways to improve manual keyboarding somewhat, increases are not significant. Optical readers and scanning devices offer hopes of freeing input speeds and sending them soaring.

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Optical readers and scanning devices offer hopes of freeing input speeds and sending them soaring.

PRESENT AND PROJECTED POLICIES OF THE J. C. P.
Congressional Joint Committee on Printing

by John F. Haley
Staff Director

. . .I shall direct my remarks to many items that should tinkle with familiarity to most of you. . .

Let us depart from the inverted conventions and try to see everything quite plainly as the verbal smokescreen lifts.

Allow me to take you back to another day a little more than five years ago. . .

In 1961 an analysis of the Federal publication indicated that approximately 20 percent of those publications were being composed on some form of automatic data processing equipment. Further analysis of these publications indicated that compromises with legibility, bulk, and printing and binding costs had been made for the sake of pure speed in composition and dissemination of the end product.

After discussions with the major publishing agencies of the Executive departments and staff of the Government Printing Office, a policy determination was made by the Joint Committee on Printing to give a mandate to the Public Printer of the U. S. to develop a program designed to give proper balance to the use of computers in the printing field. All of us concerned with this effort are fully convinced that this was an epochal event in the history of electronic composition. ..

a mandate to the Public Printer of the U. S. to develop a program designed to give proper balance to the use of computers in the printing field

Working to bring about a solution to the conflicting needs for speed in composition and desirable printing practice, this group also analyzed and integrated work that had begun in the various agencies on this problem. . . .

A subcommittee, composed of representatives of the GPO, Army, Navy, and HEW, drafted a set of specifications for the approval of the whole committee which, in turn, submitted them to the Public Printer for his consideration.

After approval of the Joint Committee the specifications were released to the industry on July 17, 1963. . .

On October 15, 1963, a total of six proposals were received from the following firms: IBM, Harris Intertype, A. B. Dick, Alphanumeric, Photon, and Mergenthaler.

A subcommittee of the Electronic Printing Committee, composed of the representatives of GPO, Navy, and HEW, assisted by Mr. Ralph Mullendore of the Bureau of Census..recommended that the contract be awarded to Mergenthaler.

contract awarded (to Mergenthaler) on March 11, 1964*

This recommendation was endorsed by the full committee and submitted to the Public Printer on January 27, 1964. On March 11, 1964, the Joint Committee on Printing approved the request to purchase two high-speed phototypesetting machines known as Linotrons. The contract was awarded on March 11, 1964.

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* two high-speed Linotrons

Even as I stand here today,* the first of the Linotrons is being prepared for shipment to the Government Printing Office where, after meeting contractual requirements pertaining to performance, it will usher in a new era in composition.

Why, one might ask, do I say that the Linotron will usher in a new era in composition?

First, I would say that we have bridged the gap that had existed in the speed imbalance between computers and composing devices.

Second, I would say that we have introduced a new technology to composition by means of cathode ray tube outputs.

Third, we have brought together with the Federal service the practitioners of two arts; namely, the art of data processing, and the art of typography. Recognition of each other's problems has been and will continue to be an essential element in the exploitation of this new era in composition.

first of the Linotrons is being prepared for shipment to the Government Printing Office*

Recognition of each other's problems has been and will continue to be an essential element of exploitation of this new era in composition.

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* June 15 and 16, 1967

THE IMPACT OF ELECTRONIC COMPOSITION ON COMMERCIAL PRINTING AND PUBLISHING

by William C. Lamparter
Senior Graphic Arts Economist
Battelle Memorial Institute

. . . . Let me explain what I mean by a commercial printing and/or publishing company.

As the word commercial implies, such a company is in business to make money.* This is an important consideration because it means that the utilization of new concepts, such as computerized composition, must either immediately improve the profitability of the business or at least offer some hope that greater profitability can eventually be realized.

commercial printing and publishing companies in business to make money.

Our definition of commercial printers also includes a number of the specialized segments of the printing industry such as the business-forms printer, the greeting-card manufacturer, the book and periodical printer, as well as the specialist in items such as direct mail, catalogs, and directories. Particularly important for inclusion in this list is the trade composition house. . . . Because of their highly-specialized situation, we have excluded newspaper. Operations that exist primarily to manipulate data -- probably by computer -- are not considered to be commercial printers, even though they may at times be concerned with printing. Government operations are also outside of our definition as are those organizations that are not profit oriented. . . .

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As a part of Battelle's research activities,** we have been conducting almost continuous field interviewing of the group of commercial printers and publishers just described. During the past five years, we have been particularly interested in photocomposition -- or as it might more properly be called, phototypesetting -- and the application of the computer throughout the graphic arts industries.

Automation in the graphic arts -- including, but not limited to, computerized composition -- has been the subject of a number of research projects. . . . In investigating this field I have interviewed a large number of printers and publishers.

The results of our discussions with publishers and printers indicate that the attitudes in the industry toward automation of the composing room are varied and often contradictory.

attitudes in the industry toward automation of the composing room are varied and often contradictory. . .

We did find that there was considerable opinion regarding the markets and production technology associated with computerized composition -- although many of these opinions were based on few or no data. The

opinion regarding markets and production technology . . . based on few or no data.

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* The many thousands of small job printers located in virtually every city, town, and hamlet in this country are prime examples of commercial printers. While many of these operations are small businesses of less than 10 employees, the category also includes medium-sized businesses that, in a few cases range up to 250 employees. Also included are the handful of large companies that make up the "giants" of the producing-printing industry.

** Battelle is a worldwide organization that does contract research in a wide variety of fields (graphic arts during the last 20 years).

repetitive nature of some opinions made us suspicious of their validity, and a little detective work resulted in tracing some of these "opinionated facts" to the same sources of information -- frequently trade magazine articles and convention speeches.

As is unfortunately the case in many areas of the graphic arts, there is a lack of comparative data for computerized composition and its reasonable alternatives. The little factual information available is all too often misused by both the printer and printing buyer in the formulating of conclusions. For example, information applicable to newspaper work has been used to draw general conclusions regarding the applicability of computerized composition for all types of composition work. Another common misuse of data is the comparison of information regarding computerized composition to similar information that concerns completely manual methods. This has the net effect of making computerized composition look more attractive than it really is. . .

While certain portions of the graphic arts labor force present a progressive image, there seems to be a general reluctance on the part of labor to accept and actually permit the application of the computer in an economical manner in the graphic arts industry.

Computerized Composition Today

The interest and controversy associated with computerized composition are as much the result of fantasy as fact. The fact of the matter is that, of the vast volume of material set in type by the commercial printer or publisher, precious little has been set on a computer. There are few publishers who have achieved a tangible reduction in their production costs as the result of utilizing computerized composition. There are few printers who can point to black ink on their balance sheet and say that it represents a profit achieved from supplying computerized composition services. . . . Superficial review articles are appearing with increasing frequency in both the business publications and the popular press. Unfortunately, this outpouring of information has too often been incomplete and oversimplified. . . .

Computers are being used by the commercial printer. There are approximately 100 to 125 commercial printers, publishers, and trade typesetters utilizing the computer for the composition function.*

A number of these computers are associated with a new kind of typographic service firm in the graphic arts. Although one of the principals of this new type of company may be an "old hand" in the graphic arts, perhaps even a compositor, these companies are characterized by their utter disregard of industry traditions and taboos. They are new companies and, therefore, are not faced with the problem of utilizing old equipment on hand as is the entrenched printer and publisher. They are data processing specialists who can look at the requirements for composition from a fresh, new viewpoint. They do not have established labor contracts

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They are new companies . . .

they are data processing specialists . . . free to hire labor at the true skill level required . . . and

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* . . . . estimate of commercial computerized typesetting installations based on a survey published in October 1966 by Composition Information Services of Los Angeles, California.

with the traditional graphic arts craft unions, and are free to hire labor at the true skill level required and pay a wage that is in direct relationship to these skills.*

they pay a wage in direct relationship to these skills;

I do not want to imply that these new installations have solved the problems associated with computerized composition. They have not, and in some instances they have created new problems. They are significant, however, because they can bring a new unfettered view to the composition problem and they are able to use low-cost labor when it is appropriate.

in some instances they have created new problems . . . however, they can bring a new unfettered view to the composition problem . . .

Despite the problems, computers are being used by commercial printers and publishers to produce composition. One might well ask, "Why?"

Some composition jobs are computerized because the need for rapid output -- speedy service to the customer -- overrides conventional cost considerations. When unusual speed requirements are not a job condition, the kinds of composition work that can be economically produced on a computerized composition system are limited. Standard straight matter that requires keyboarding, hyphenization, and justification can rarely be done economically on a computer. When the setting of composition can in some way be combined with data manipulation functions, total production costs drop sharply and the computerized approach becomes economically feasible on a total product production-cost basis.

Standard straight matter that requires keyboarding, hyphenization, and justification can rarely be done economically on a computer.

Utilization of the computer becomes attractive when a significant number of keyboard strokes can be saved. Of course, the ultimate in saving keyboard strokes is when a secondary publication can be produced without any keyboard strokes. Thus we can get the output tape for a secondary publication at a minimum cost.

A similar situation exists when an existing publication is to be updated. By merging corrections and new material with old material, the computer can be used to eliminate rekeyboarding the unchanged older material. When information is already in the computer for some other purpose, keyboarding is sharply reduced or eliminated for the production of tape. Any time that maximum use can be made of the data-processing capability of the computer, the composition function becomes economically feasible. This is an important consideration because most commercial printers are not in the data manipulation business.

Any time that maximum use can be made of the data-processing capability of the computer, the composition function becomes economically feasible. . . Most commercial printers are not in the data manipulation business.

The Future

It appears that the printer must change his thinking and become involved in data manipulation if he is going to earn a profit in the computerized composition business.

In the future, the compositor may become merely the operator of photocomposition or character-generation equipment. The equipment would be activated by tapes supplied by the customer. This approach will, of course, reduce the value added to the final printed

In the future,
the compositor . . . merely the operator of photocomposition or character-generation equipment,
. . . activated by tapes supplied by the customer . . . [since]

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* In an effort to keep costs to a minimum, some of these new service houses have made arrangements with local housewives to perforate the input tape in their homes.

product by the printer. The acceptance of outside produced tapes is a practice that is prohibited in many labor contracts. This may cause considerable problems in the traditional graphic arts shops.

In the future it does seem probable that there will be: (1) some composition jobs that cannot be computerized economically, (2) some that can be computerized, (3) some that require the printer to become involved in data manipulation, and (4) some where the customer prefers to do the data manipulation and furnish the output tape to a composition specialist to be run through his photocomposition or character generation equipment.

The road to computerized composition is difficult and, despite manufacturers' claims and glamour talk to the contrary, much pain, blood, sweat, and tears are necessary to put computerized composition on an economical basis. . . . Composition jobs computerized for the first time are almost never less expensive than conventional typesetting approaches. Even on subsequent runs of the same material, computerized composition must frequently be sold on the basis of a savings in total preparation costs. Unfortunately, customers frequently do not know what their total costs really are.

acceptance of outside produced tapes is prohibited in many labor contracts, this may cause considerable problems

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Conclusion

Computer composition can be economical when the nature of the work permits savings in keyboarding.

Commercial computer composition is barely out of its infancy. Its development may well precipitate changes that improve the flow of communications even though these changes may upset traditional functions and patterns of operation in the graphics.

Like many of the commercial printers and publishers that Battelle has been interviewing, we are optimistic that computerized composition will find a significant place in commercial printing.

A BRIEF OVERVIEW

by Samuel N. Alexander
Senior Research Fellow
Office of the Director
National Bureau of Standards

If the Government has a characteristic output. . . it is printed matter in large quantities, amply supplemented by multilith and mimeograph output. . .

. . . . I did not have a prior appreciation of the extent of the Government's dependence on and the variety of its activities in the printing and graphic arts areas. I presume there are some exceptions but it seems as though the Government is involved in printing and graphic arts activities in practically every form in which they are known today. As a consequence, the Government will very likely become the proving ground for a wide variety of innovative practices because of our pioneering in the application of these new tools.

the Government will very likely become the proving ground

I would hope that in these activities there will be a better balance in the proportions of accomplishments reported versus advance publicity on "good intentions" than was the case with the introduction of automatic data-processing techniques into our Government practices. Here publicity consistently tended to run well ahead of accomplishment.

I would hope. . . there will be a better balance in the proportions of accomplishments reported versus advance publicity on "good intentions"

I hope that this community will exercise a little more restraint in reporting its progress and that there will be a careful distinction made among "what-we-are-planning-to-do," "what-we-are-about-to-do," and "what-we-have-done.". . . . There is so much at stake that we cannot afford to take excessively large steps and have temporary failures, backups and start-overs. . .

I hope that. . . there will be a careful distinction made among "what-we-are-planning-to-do," "what-we-are-about-to-do," and "what-we-have-done."
There is so much at stake that we cannot afford to take excessively large steps and have temporary failures, backups and start-overs. . .

We should not each separately have to find out about the common "booby-traps," and disarm them one at a time, each unaware of the other's experience. . . . One must often depend entirely upon the supplier of the equipment for information on the booby-traps that he has observed in his contacts with other customers. . . . The techniques here under discussion are raising expectations that we may soon achieve a new economic balance point in the creation of publications. The relationship I have in mind is between the cost of preparing the material for publication and the follow-on cost of printing and binding. . . . The indications are that -- the not distant future it will become feasible to justify quality type for runs as small as 2,500 and perhaps the break even point may be pushed as low as 2,000. . . .

not distant future it will become feasible to justify quality type for runs as small as 2,500

One of the purposes of the proposed trail-blazer operation is to derive firm information about some of these "trade-off" points. The other objective to try to achieve is to examine the total package of skills complements that will become associated with these new techniques. This is needed. . . . to properly advise with respect to the shifting demands that surely will arise from this new technology. The data processing area is in a rather unhappy state in this respect because of the lack of a purposeful effort to systematically obtain this kind of information in advance of urgent need. . . . all the way from originating the publication to its output and distribution.

ELECTRONIC COMPOSING SYSTEM APPLICATIONS

by John J. Boyle
Special Assistant to the
Production Manager for Electronic
Printing
U. S. Government Printing Office

This afternoon[*] I would like to talk about some of the accomplishments of the past four years. What have we learned? What type of work appears to be most practical by this method? What are some of the problems that were encountered and what problems do we see in the future?

Four years ago, there were no available composition programs for the IBM 1401 computer. We had on our staff trained 1401 programmers, and computer time available to do a limited amount of composition, so a decision was made to write computer typesetting programs for Linofilm and linecasting machines utilizing available computers.

Mergenthaler at the time had started to write a Linofilm program and we used this as a nucleus to adapt to the specific needs of Government publications. IBM had a typesetting program for the 1620, and with their help, the logic was used to write a 1401 hot-metal composition program. . . .

Our feeling was that typesetting programs should be written so that any style or format could be produced by the computer, within the limitations of the typesetting machine, by very simple changes in the instructions or parameters, or by codes introduced into the input.

This is the ideal. In practice this theory does not always work. Regardless of the knowledge of composition and its variables, each new job will create problems in a master composition program that require additional programming and debugging. In order to get into production we decided to find a publication that had an application and solve the problems one at a time.

The Library of Congress Subject Headings, Seventh Edition, was our pilot project in computer composition. This 1400-page book, containing 326,000 lines, had for many years been produced by hot metal or Linotype, corrections being inserted into standing type. Additions and changes to the previous edition had been issued monthly as cumulative supplements and this type was also held in storage.

When the Library of Congress decided that it would be necessary to print a new edition. . . . we were faced with the job of removing 1,368 pages from type storage and manually inserting 86,000 lines of additions, corrections, and deletions.

We felt that this job was a natural for a computer system and with the cooperation of the Library of Congress the necessary programming was started so that we could convert the material to magnetic tape files. . . .

What have we learned [last] four years?

. . . what problems do we see in the future?

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IBM had a typesetting program for the 1620. . .

The Library of Congress Subject Headings, Seventh Edition, was our pilot project in computer composition.

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[*] June 15 and 16, 1967

The manuscript was converted to paper tape in TTS code on the Justowriter perforators...This paper tape was converted to magnetic tape on the converter, . . . was processed through the computer using a file organization program. . . . The file was then listed on the computer printer to create a proof. This proof was read, corrections were keyboarded on the perforators, corrections were converted to magnetic tape, and the locators on each correction were used by the computer to correct, insert, or delete a line in the original magnetic tape to create a clean tape.

This magnetic tape was then processed on the computer which had been programmed with the Linofilm composition program to produce a new magnetic tape written in the language of the phototypesetter.

The Linofilm magnetic tape was converted to 15-channel paper tape which was used to drive the photo unit and produce galley paper positives. . .Negatives were made, and the Seventh Edition was printed from offset plates. . . .

. . . . Several computer programs in addition to the composition program are involved. The cost of converting the data to machine readable language is comparable to resetting in hot metal type. So where is the payoff? How do we save the agency money on this job?

We have 3 reels of magnetic tape instead of tons of metal to store. When we are ready to print the next edition the magnetic tapes of the supplements will update the basic edition at much higher speed and lower cost than a craftsman manually inserting type slugs... Manual composition, some of the proofreading, and manual page makeup will be eliminated. The publication will be produced on a much shorter time schedule and the data will be more current.

Let's look at another early example -- the classification index of the Patent Office Weekly Official Gazette. . . . A total of $68,409 patents were issued in 1966.

Prior to computer composition, the weekly index was set on the Monotype, proofread from copy,* corrected, made up into pages, proofread again from copy, and corrected. It was then ready for press.

... Again with Mergenthaler's help, programs were written so that we eventually were able to put the weekly cards into the computer which assigned column identification to each entry, sorted the lines into columns, and wrote a magnetic tape for Linofilm to produce completely made-up pages ready for offset printing. This

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Patent Office Weekly Official Gazette /classification index/

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* Now where did the copy come from? Back at the Patent Office as a part of the issuance procedure, a keypunch operator punched an 80-column tabulating card which contained the information we wanted to set, plus other information necessary to the Patent Office. The tab cards were listed on the printer and the three fields of information became our manuscript copy.

So what did we do? We duplicated the keystrokes on a Monotype that the operator had already accomplished on the keypunch. We made keyboard errors which had to be corrected and revised. In addition, the 52 issues of weekly indexes were not practical to merge and consolidate by hand and in order to produce the annual index we reset the entire job.

sounds like a lot of work for the computer but it takes only a few minutes each week. There is no composition, no proofreading, and no makeup performed manually on this job. At the end of the year the cards are written to magnetic tape, tape is sorted, and the Printing Office reruns the job for the annual. Page costs are less than one-third of the hot-metal rate. . . .

While we were working on these jobs another very important series of publications was brought to our attention. The Department of Defense Technical Abstract Bulletin and the Commerce Department U. S. Government Research and Development Reports are announcement journals that contain abstracts of documents available in the Defense Documentation Center and the Clearinghouse for Scientific and Technical Information.

The abstracted information was being keyboarded on paper tape perforators for input to the computer to create a base for information retrieval. As a byproduct of computer input the perforator produced a typescript proof which was pasted up to use as camera copy for offset production.

It was desired to improve the typographic quality . . . . and reduce the number of pages. . . .

Again, programs were written to edit the material and assign typesetting information which had not been keyboarded in the original perforation. Modifications were made to the composition program to handle this job. We now produce both of these publications in graphic arts quality, in nearly 40 percent fewer pages over typewriter copy, on a fairly tight schedule every two weeks. . . . Actually, from the time of the initial study and decision to proceed, it was nearly one year before we were in full production.

I have purposely selected these three publications to point out the flexibility of the input. The Subject Headings was produced from paper tape keyboarded in the Government Printing Office specifically to create a master file for future printing. The Classification Index* was produced from an existing tabulating card file without any printing or typesetting information. The Technical Abstract Bulletin and the USGRDR were produced from a magnetic tape generated by a Univac 1107 computer. We have in regular production a large publication for the Department of the Army which comes from an RCA 301 computer. Magnetic tapes are received regularly from the National Bureau of Standards IBM 7090 computer at Boulder, Colo. . . .

The Linotron hasn't been mentioned up to now because the problem is not that different. If we can produce the right kind of work economically on comparatively slow equipment, this should be sufficient proof that we can show dramatic savings on a machine that is 100 times faster. A whole new area of computer composition will become feasible with this added speed and reduced character cost.

Page costs are less than one-third of the hot-metal rate

The Department of Defense Technical Abstract Bulletin and
The Commerce Department
U. S. Government Research and Development Reports announcement journals

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"Subject Headings:"
from paper tape;
"Gazette:"
from tabulating card file;
"Technical Abstract and USGRDR:"
from magnetic tape

Linotron hasn't been mentioned . because the problem is not that different. If we can produce the right kind of work economically on slow equipment, this should be sufficient (!?) proof that we can show dramatic savings on a machine that is 100 times faster.

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*Gazette

In summary, I would like to point out that computer composition is not going to solve all of your composition problems . . .

The determining factor must be the cost of conversion from the present method to the new method and the determination whether that cost can be recovered in a reasonable time by savings in other areas.

It has been our experience that considerable time elapses and considerable sums of money are spent before a publication becomes an actuality. . . .

Keep these goals in mind and use them as guidelines for the selection of suitable work:

1. Reduction in cost by reduction in bulk of computer printout.
2. Reduction in cost by elimination of rekeyboarding data already in machine-readable language.
3. Reduction in cost by elimination of manually correcting standing type on recurring publications.
4. Improved schedules and more current publications.
5. Improved quality and upgrading of Government publications.

The determining factor must be the cost of conversion from the present method to the new method and the determination whether that cost can be recovered in a reasonable time by savings in other areas.

COMMENTS

by Mary Elizabeth Stevens
Center for Computer Sciences and
Technology
National Bureau of Standards

I would like to remind you of the millions and millions of printed pages that are already in existence and for which we have no capturable machine-form versions. There are similar problems with the continuing flood of publications from all over the world. In many cases we will have access to neither the manuscript preparation nor the typesetting tapes. If we wish to process this great bulk of information by machine, then optical character recognition techniques may prove to be the only economic means of input.

If this proves to be the case, we will need to know certain things. Thus, at a symposium on mechanized abstracting and indexing held in Moscow last September[*] under UNESCO auspices, one of the recommendations that was submitted to UNESCO related to these needs. This recommendation was that all printers of books, periodicals, journals, and the like, be asked to provide in each issue in a special place a full set of all characters and symbols in any font or fonts used in that particular book or journal. The implications for the development and use of OCR techniques are obvious.

My second point also relates to automatic data processing of printed text, but in a slightly different sense. Those of us who use computers for language and text and bibliographic data processing have, like other computer users, asked you who are members of the graphic arts industry to give us back high typographic quality and still keep compatibility with computer speeds of output. And this, I think, you are well on the way to doing for us. However, some of us would now like to ask you to back off just a little on the typographic quality on one minor point. Please be sure you give us, even with variable spacing, some means of differentiation between the period used to end a sentence and the symbol used to indicate an abbreviation or as a decimal point, whether by special spacing or by new symbols, and whether or not this produces "rivers" of white on the page.

I would like to remind you of the millions of printed pages that are already in existence and for which we have no capturable machine-form versions.

1966 under UNESCO auspices: symposium on mechanized abstracting and indexing

recommendations was that all printers of books, periodicals, journals, and the like, be asked to provide in each issue a full set of all characters and symbols in any font or fonts used in that particular book or journal.

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[*] September 1966, Symposium held in Moscow under UNESCO auspices.

Printing Magazine/National Lithographer, October 1968

PROGRAMMING
CRT'S FIRST GENERAL BOOK

by Peter Mollman
Production Manager, Trade
Harper & Row Publishers, New York

High in Harper & Row's multi-packaged payout is a set of programs which, with relatively minor adjustments, now can be adapted to similar formatted books.

Setting a 60,000-word mystery book via CRT (Cathode Ray Tube) composition was an experiment -- to see if the high-speed process could give us the sharp, clear, book-quality type and correction capability we needed to offset the spectre of rapidly rising per thousand em rates in hot metal.

Automation with hot metal, we figured, had gone about as far as it could go. So, beginning with a discussion in September, 1967, between myself and representatives of Haddon Craftsmen, a Scranton, Pa., firm which produces many Harper & Row books, we evaluated alternative processes. Haddon had contacts with RCA and had contracted to set a book at Videographic Systems, Inc., Hauppage, N.Y., a composition service bureau utilizing an RCA Videocomp.

In theory, CRT composition should have been the answer we needed because of its high-speeds and flexibility.

The text was simple straight matter with some extract.

We also set a simple back-up. Haddon Craftsmen would punch TTS tape on the book and hold it. If the experiment didn't work, we could always run the tape through the TTS Linotypes and produce the book on time.

There were just a few type faces developed at that time. We selected one called Videocomp Janson

Characters Clean and Sharp

Within a week, RCA's computer expert came back with a page of reproduction copy.

The next session concerned book composition methods, procedures and style. We went over editorial styling.

In theory, the programming sounds simple. A program for the basic page length was set up, with running heads. A program for extract and a separate extract were put into the computer. Another program handled chapter openings. Italics and small caps were to be handled by

CRT FOR STRAIGHT MATTER?
[as answer appearing in same issue]

by Henry Sedgwick
President, Sedgwick Printout Systems,
New York

The application of computer-controlled, ultra high-speed typesetting to book production -- principally textbooks -- is an area of some controversy. It's hard to see how mighty character generators such as CRT machines, that lease, along with the computer, for about $20,000 per month, can compete with Linotype which you can buy for about $40,000 or a second-generation phototypesetting system which might cost about $50,000. This is especially so when you consider that the high-powered gear saves nothing on keyboarding or proofreading which, with page make-up, is at least 80% of per-page composition cost in book work.

Looking at per-age machine cost alone, the super-typesetters would have to set about 3,300 pages per month, or about one-half million book pages per year (more than 1,000 books), just to get the cost down to $6 per page. I don't know if there are many book manufacturers doing that kind of volume. And I question the economics further if, to a machine cost of $6 per page, one adds at least $8-$9 for keyboarding and proofing.

The glamor attached to computer-controlled typesetting notwithstanding, what cost glamor if the page rate on a trade book goes from $6.50-$8 via conventional methods to at least $12-$15 on an ultra high-speed typesetter?

Advantages in Production Control

But there's another side to the story. Current production methods involve author, editor, art and production departments and the typographer in an impossible series of communication and co-ordination difficulties.

In the existing system, the author creates the data and submits a manuscript to the publisher. Inevitably, there's at least one re-typing of the manuscript before it goes to the typographer -- who then solemnly keyboards the data all over again either on-line or on tape.

In this system, the publisher and typesetter spend half their time putting errors into the manuscript and the other half getting them out! How many times have we seen corrected lines, or AA's returned from the typesetter with new and imaginative errors inserted?

normal shift operators, similar to the TTS units.

On Nov. 15, we went to Videographics to see the first run-through.

The punched paper tape moved first onto a magnetic tape, at a speed of 300 CPS. The magnetic tape then ran through the first stage of the RCA Spectra 70/45 computer, which checked for minor errors in input and controls. A computer printout could be read at this stage, which had line/character co-ordinates.

The second stage of the computer run-through did three things: hyphenation and computations for pagination for all types of pages; transferring the internal computer code to a CRT code; and, finally, pulling from a core disc the actual data on the proper fonts to be used. The computer read this tape at a speed of 30,000 cps.

The third, or output stage, actually pulled the Videocomp data to create each character on the cathode ray (each translated into a series of dot segments) from a core disc and transferred the Videocomp-ready information to tape. At this last stage, a light indicates which page is being worked on, so it is possible to run the magnetic computer tape to a precise spot and then pull only what is needed on to the tape.

After the orientation we did a run-through of the first chapter. It took about 15 minutes from tape insertion until the first page of clear, black reproduction copy was pulled. And a new page came out about every 10 seconds.

We also decided to run through a quick-change experiment. With this run-through we were convinced that we were over the major hurdle, and only the minor details were yet to be solved.

We took the chapter back to the Harper office, and with the designer made some basic decisions.

'If At First You Don't Succeed'

The go-ahead was given and several weeks later we got the complete book. This was a new experience for the proofreading sections at Harper, so they received a basic orientation on how the system worked.

Bound galleys were produced from the master set by Xerox-microfilm at about the same cost as normal bound galleys.

The second run-through solved most of the problems.

There's another problem. The moment the publisher hands his manuscript to the typographer or book manufacturer he has completely lost control of the data creation and production schedule. The new technology offers an opportunity to restructure this chaos.

In-house Data Creation

The new technology makes it possible to convert the manuscript to machine-readable form in one location and typeset in another -- giving the publisher the opportunity to take in-house the activity of what the computer crowd calls data creation. The publisher can prepare a tape, which -- after further processing for insertion of page, format and typesetting codes -- will be ready for typesetting first in galley, and then final page form. This structure puts the responsibility of valid data creation where it belongs and gives the publisher far greater control over production schedules.

Finally, a perennial problem in conventional methods of textbook production has been that the typesetting cycle is simply too long for the majority of textbooks, which must have current information when published. Time span can run from an average of six months to 18 months and longer. Data transformed into machine-readable form can readily be updated.

I don't think that the publisher using the in-house system mentioned above would net a reduction in typesetting costs. Using our price structure as an example, typesetting costs, after receiving a fully formatted magnetic tape, would run no more than $2.50 per page. This would include two galley runs and final page make-up.

This cost does not include the step between the publisher's keyboard and our typesetting system -- insertion of formatting and typesetting codes. A fair guess on that would be another $4-$5 per page. Nor does the cost include keyboarding or proofreading which -- in the system I've described -- becomes the publisher's in-house cost.

The publisher's immediate advantages, then, lie in the control of data creation and production scheduling. Ant that cannot help but be of substantial interest.

The proofreaders found that once the type was correct it stayed correct.

The final repros were taken to RCA Graphic Systems headquarters for conversion to film positives used to make negatives for producing the book by offset.

Correcting the manuscript proved to be as easy as advertised.

Every element that we had worried about was solved.

Modern Lithography, April 1969

McCALL and the COMPUTER

One of the first printers to seriously investigate the commercial feasibility of the new computerized cathode-ray tube electronic typesetting techniques was McCall Printing Co....

To form its Graphics Research Laboratory, McCall Printing simply took over...the former headquarters of RCA's Graphic Systems Div., Dayton N J

CRT Typesetting Commercially Feasible

Two years later, McCall's Graphics Research Laboratory has developed an adequate base of computer programming techniques to make CRT typesetting commercially feasible for specific jobs (and along the way has had to develop some of its own equipment), so that the emphasis at the plant is now on typographic production rather than on development work*..But magazine composition has proved to be the area for which CRT typography is least suitable, at present, because of the variety of page formats and display type faces used by magazine designers.

magazine composition has proved to be the area for which CRT typography is least suitable

...Computer programming costs for a single page format run from $500 to $3,000 each, so that Videocomp is only practical for composition of a large number of pages which use the same "rules" for format.

...Computer programming costs for a single page format run from $500 to $3,000 each

Computerized CRT composition does have a competitive edge according to McCall GRL executives, for directory or reference work typesetting jobs, where "standing" type is updated for successive editions, or where the computer arranges information which is keyboarded in random order. Mr. Moore anticipates that about 80% of GRL's sales volume in 1969 will be in this kind of typesetting, with the remainder in miscellaneous "straight composition."

Mr. Moore anticipates that about 80% of GRL's sales volume in 1969 will be in this kind of typesetting with the remainder in miscellaneous "straight composition."

Composition for college textbooks may be another significant market for computerized CRT typesetting, Mr. Moore believes. In order to protect sales of new texts when second-hand copies begin to show up in the bookstores, the publisher usually issues a new edition every few years.** To obsolete the previous edition the new edition is normally reset in a new typeface and the format rearranged so that the same material is on different pages in the two editions.

...textbooks...significant market...

To obsolete the previous edition the new edition is... reset in a new type face... same material is on different pages in the two editions.

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*McCall executives originally hoped that CRT system might be useful for typesetting for magazines (McCall's Dayton Div., "the world's largest printing plant," produces more than 60 magazines, including many of the largest national publications).

..."the world's largest printing plant"

**...now able to produce a new issue every two weeks instead of once a month or the major book publisher which will be able to issue a revised edition of a dictionary every one or two years, instead of the longer intervals required when using traditional methods.

...able to produce a new issue every two weeks instead of once a month...

On typesetting for the first edition, computerized CRT typesetting is somewhat more expensive than hot metal...

Magnetic tape keyboards are available from data processing equipment manufacturers but are designed as replacements for key punches while keyboards offered by graphic arts manufacturers for typesetting primarily produce paper tape according to McCall officals. Paper tape is a big drawback in computerized typesetting because of the relatively slow speed of paper tape readers. A magnetic tape reader can feed data into a computer at 150 times the speed of a paper tape reader

Paper tape is also susceptible to machine error (inoperative punches incomplete perforation reader unit errors caused by splices, etc.)...

From the corporate viewpoint McCall Printing's short term goal in entering the CRT composition field was to keep pace with rapid change the computer has introduced to the printing and publishing industry and to be in a position to offer customers the benefits of combining data retrieval techniques with photocomposition...

From a longer-range viewpoint, the most important rationale for entering the CRT composition field is the belief of McCall Printing executives that the time is not far off when photographic input will be required for all processes, including letterpress....

While computerized compositon has shown the least promise to date in publications field Mr. Harris reports growing interest in the process by publishers of magazines which have a highly consistent format and urgent deadlines, such as news weeklies (McCall plants currently produce Newsweek and U.S. News and World Report.)

While admitting that computerized composition is quite unlike its traditional activities, McCall Printing Co. believes the new technology will significantly alter the complexion of the printing and publishing business -- and is willing to pay the price of staying ahead of change.

On typesetting for the first edition computerized CRT typesetting is somewhat more expensive than hot metal...

...A magnetic tape reader can feed data into a computer at 150 times the speed of a paper tape reader.

Paper tape is also susceptible to machine error ...

...computerized composition has shown...growing interest in the process by publishers of magazines...

...McCall Printing Co. believes the new technology will significantly alter the complexion of the printing and publishing business...

/text (in the original) appearing under pictures:7

Typefront programs are stored on disc pack unit for retrieval by main computer.

Proofreaders check manuscript against conventional computer print out before the job goes to the Video comp.

Card punch keyboards are used for input of programming and for insertion of corrections. Finished tape output of computer is transferred to the Videocomp control unit, which drives the CRT image-generating unit.

Proofreaders check manuscript against conventional computer print out before the job goes to the Video comp.

British Printer, July 1969

by Lawrence Wallis

COMPUTER SETTING METHODS, COST and PERFORMANCE

Complete automation of typesetting will probably remain a technologist's dream. ... OCR has a long way to go before reaching full technical maturity. Dr. M. Spooner of Cornell Aeronautical Laboratories stated some months ago that the process was 'at least ten to 20 years away from reading handwriting at a practical level'.

Any discussion of automated typesetting seems to flounder at the input stage, where the problems of manner are manifold. Typesetting demands a preponderance of data preparation and relatively little computer processing - whereas in many other data processing fields the requirements are reversed, with small amounts of data undergoing extensive computer manipulation. In the latter case, the user gets more data out of the computer than he puts in, while the typesetting plant has an equivalence of input/output volume: a factor tending to pare down operating margins. Doubtless this characteristic of typesetting has inclined to militate against the profitability of current computer installations within the trade. . .

Typesetting automation should not be looked at in isolation or as an end in itself; the subject needs to be related to the basic structure of the industry.

It is worth recalling that some 60 per cent of printing companies in the UK have fewer than 25 employees; ... Even in the USA around 80 per cent of the printing establishments have payrolls of fewer than 20 people.

Nevertheless, a trend towards group activity through firms merging or entering into associations can be discerned on a world-wide front, . . . about 100 plants account for one third of print sales in the USA. . .

Systems in Practice

Businesses in the upper reaches of the industry are obliged to investigate, and possibly apply, new typesetting techniques for four reasons:

(1) to stabilise spiralling production costs;

(2) to overcome a shortage of manpower, whether skilled or unskilled;

(3) to combat increasing competition from television and other mass communications media; and

Lawrence Wallis, formerly Systems Adviser to the Monotype Corporation, recently joined Crosfield Electronics' phototypesetting division. He was for many years a teacher of composition methods.

Any discussion of automated typesetting seems to flounder at the input stage. Typesetting demands a preponderance of data preparation and relatively little computer processing

Even in the USA around 80 per cent of the printing establishments have payrolls of fewer than 20 people.

Nevertheless, a trend towards group activity through firms merging or entering into associations can be discerned on a world-wide front; about 100 plants account for one third of print sales in the USA.

(4) to satisfy the growing market for printed matter and to handle quickly the explosion of information in the scientific and technological fields.

Some indication of the potency of these factors has been given in successive surveys of computer typesetting installations published by Composition Information Services of Los Angeles. Only 77 plants were recorded for 1964 as compared with over 500 in 1967, and the number for 1968 showed another marked increase to 821.

Surveys of computer typesetting installations recorded
77 plants for 1964
over 500 plants for 1967
821 plants for 1968.

Whether the 800-odd decisions to install a computer for typesetting control were all reached on a rational basis must remain a moot point, thought it seems hardly likely, since most printers show an alarming lack of awareness about the running costs and operational performances of their existing systems. Any savings that a computer may bring can be reliably assessed only on the basis of this kind of knowledge. Investment in a computer strictly for typesetting purposes can be supported only by three potential areas of saving:

Whether decisions were all reached on a rational basis - most printers show an alarming lack of awareness about running costs and operational performances of their existing systems.

(1) increased keyboard production;

(2) reduced handling of matter in a caseroom or film make-up department; and

(3) more efficient use of typesetting machine time.

In other words, the extra cost of computer processing must be recouped by savings elsewhere in the production chain.

The extra cost of computer processing must be recouped by savings elsewhere in the production chain.

It must be appreciated, too, that with a 'straight throughput computer system costing about £8,000 +, such as Justape or PDP-8L, the gains and economic recovery must be sought exclusively from boosted keyboard productivity and enhanced output from typesetting machinery. It becomes extremely difficult for the book and general printer to justify an investment on these grounds - although it would be hard to imagine a more efficient installation than the Linasec at Richard Clay Ltd, Bungay, processing tapes for a battery of tape-operated linecasting machines engaged on paperback book production. Nevertheless, a single-pass computer system will appeal in general more to a newspaper plant, where the frequency of the end-of-line cycle on narrow measures provides the conditions for a significant increase in perforator output when transferring from justified to unjustified tape production. About 30 characters are contained in the average single-column newspaper line as opposed to some 50 or 60 characters in a book measure. Thus a newspaper production manager may well anticipate about 50 per cent more benefit from a computer at the data preparation stage than his counterpart in a general printing plant.

A single-pass computer system appealing more to a newspaper plant.

Newspaper - About 30 characters in the average single-column line - 50 or 60 characters in a book measure. Thus newspaper about 50% more benefit at data preparation stage than a general printing plant.

Keyboard Speeds

Statistical expressions of the increases in keyboard productivity associated with a changeover to unjustified tape usually take the form of nebulous percentages, whereas the genuine seeker of information really wants to know the keystroking rates attained with and without the aid of a computer. Alas, I am aware of very few figures of this nature. However, a consensus of published computer-controlled typesetting experience suggests that on single-column news the improvement in productivity will be about 15 to 25 per cent (some have been less fortunate), so that a book printer employing wider measures should not expect much more than 7 to 10 per cent. Recent research suggests that these figures are quite realistic. The inherent skills of keystroking apply equally to the punching of justified and unjustified tapes; therefore, to expect an increase greater than those indicated, from the installation of a computer alone, is being somewhat optimistic. . .

For the book and general printer, often using Monotype machines, the single-pass computer system would seem to offer very little beyond the 10 per cent or so increase in keyboard productivity. Multi-pass computer systems appear to be much more promising in these areas of the industry. . .

With a multi-pass system, a book and general printer is offered wider operating margins due to computer correction and page make-up routines that reduce the handling of metal and film in the composing room. Potential improvement in keyboarding output ensues as well. Published work studies have shown that some 40 to 50 per cent of caseroom time is not uncommonly spent on corrections, while page make-up must account for a good proportion of the remainder.

Corrections

In order to effect tape-merged corrections by computer, an interim proof becomes vital before the copy is finally committed to metal or film; up to now this has proved to be something of a stumbling block... [In other words,] the computer print-out and hard copy will serve for in-house checking only. ... And one is left with the daunting prospect of tape-operated line-casters introducing a mechanical error of 2 to 3 per cent (sometimes more), which largely negates the object of completing corrections at the computer processing stage. Such problems incline one to the view that a cheap single-pass computer system is much more apt for a hot-metal plant, unless other tasks are being integrated as well.

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The inherent skills apply equally to the punching of justified and unjustified tapes.

For the book and general printer, single-pass computer system offer little beyond the 10 per cent increase in keyboard productivity. Multi-pass computer systems appear to be much more promising.

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tape operated line-casters introducing a mechanical error of 2 to 3 per cent, which largely negates the object of completing corrections at the computer processing stage.

Hot-metal Monotype machines are mechanically much more reliable and accurate than tape-operated linecasters, but one encounters the encumbrance of an off-line tape conversion process to establish a link with the computer. . .

Additionally, the kind of work produced on Monotype machines often cannot be adequately reflected by a print-out or hard copy.

Proofing

Photosetting equipment would seem to be much more compatible with a multi-pass computer schema and the two are complementary. With medium and high speed equipment, the output machine can be employed not only for the production run of film or paper, but as a proofing device as well.

Some photosetting machines have normal and high-speed modes of operation, the former to give the best quality of image for the finished job and the latter to provide a somewhat degraded image for proofing purposes. As an example, the Linotron 505. . .

. . .Speed of character production becomes the key factor in this matter, since a double pass through a photosetting machine producing tens, hundreds, or thousands of characters a second is quite feasible, as compared to some 3 to 7 characters a second with hot-metal equipment.

Some photosetting machines have normal and high-speed modes of operation

Linotron 505 writes out in finest definition at around 70 a second debast version of same character at around 180 a second.

Proofs from a photosetting machine (though of degraded quality in some cases) closely simulate the ultimate job. . .

Several book and general printing firms are at present engaged in the launching of production schemes involving the double-pass technique through a photosetting machine coupled with computer control and corrections.

Several book and general printing firms at present engaged in launching double-pass technique through photosetting machine

Three well-known British book-printers have each installed an Elliott 903 computer and a Photon-Lumitype 713/30. . . .

. . . . one of the firms has indicated that after the production of only a few books the projected costs appear to be rather better than those for Monotype composition. . .

. . . . Obviously for directory work and the like, demanding an updating and sorting capability, the use of magnetic tape may be advisable, but it should be remembered that magnetic tape operations demand a conditioned environment which could absorb quite a bit of capital. Not so long ago magnetic tape was considered to be an essential part of a multi-pass computer typesetting system, as evidenced by the installation at Rocappi Ltd: a salutary comment on the pace of modern technical progress.

for directory work and the like magnetic tape may be advisable, but be remembered that magnetic tape operations demand a conditioned environment

It is unlikely that newspaper printers will view correction routines in the same way as general printers. . . . Irrespective of whether a newspaper is set in hot metal or in a photoset medium, the business of corrections can be most quickly achieved at justifying keyboards and by manual insertions in the page.

Types of Computer

Most people in the industry are now familiar with the existence of two groups of computers: (1) single-purpose machines, and (2) general-purpose machines. In the early days of the technology, the special-purpose machine was far and away the most popular, but the pattern is changing. Of the total installations recorded by CIS in 1966, nearly 51 per cent were special-purpose computers, but in 1967 and 1968 the share had dropped to 47 per cent. . .

Of the total installations recorded by CIS in 1966, nearly 51 per cent were special-purpose computers, but in 1967 and 1968 the share had dropped to 47 per cent.

The main difference between special-purpose and general-purpose machines is that the former have programs wired into the hardware, while the latter have stored software programs that can relate to a variety of functions.

general purpose machines have stored software programs that can relate to a variety of functions

. . .special-purpose computers have essentially wired-logic programs but with character widths, etc., stored on a magnetic drum or in a magnetic core.

In some respects single-purpose machines still have certain attractions. They can be easily integrated into an existing typesetting system.

. . .the biggest disadvantage of a wired-logic special-purpose computer is its inflexibility. . . .

Unless a printer can define with certainty the models of typesetting machinery and classes of work that he will be utilizing and producing for the next five to ten years, an investment in a special-purpose computer hardly makes sense. Provincial newspaper plants and some book printers may well be in this kind of position as far as typesetting goes and uninterested in the broader data processing aspects. [!]

General-purpose models

. . .In the typesetting field the smaller general-purpose machine, instanced by the IBM 1130 and the PDP-8 series, has made the deepest inroads. It is interesting to observe, too, that most of these general-purpose machines have been used in a special-purpose manner for typesetting. . . .

In the typesetting field the smaller general-purpose machine has made the deepest inroads

The speed of the punch provides some idea of the output that can be obtained. With regard to magnetic core storage, the minimum amount represents that necessary for running a typesetting program, but the maximum ought to be borne in mind where expansion into data processing is contemplated. . .

A manufacturer must strive for overall market acceptance and must necessarily deal in technical generalities. Consequently, a program emanating from a manufacturer will be quite rudimentary in the typesetting sense: a viewpoint that I have aired consistently since 1964 and one that has been repudiated by computer manufacturers with equal constancy and vigour.

Special Programs

. . .Unless a printer is dealing in a repetitive and uniform product, like paperback novels, magazines, or newspapers, the software supplied by a manufacturer is liable to be deficient. Therefore, a book or general printer (and I suspect others as well) must be prepared to seek alternative solutions. There appear to be three avenues worthy of exploration.

Other Applications

. . .One supposes that the most profitable exploitation of a general-purpose computer for composition occurs when data processing and typesetting interact in some ways. . .

Directories, parts lists, electoral rolls, concordances, statistical and mathematical tables are ideal subjects for computer typesetting, but another fruitful outlet must be work that involves a high proportion of labour costs, particularly at keyboards.

another fruitful outlet must be work that involves a high proportion of labour costs, particularly at keyboards

Maths Setting

Mathematical setting, along with heavy tabulations, must come within this category. Character selection and the proper arrangement of formulae are the principal difficulties associated with mathematical work. Hitherto the research into the computerization of mathematical composition has been somewhat disappointing, as evidenced by the American Mathematical Society developing a mnemonic system of keyboarding that seemed to complicate rather than simplify matters. . . .

. . . the research into the computerization of mathematical composition has been somewhat disappointing

Clearly the problems of character selection arising from the wide range employed are best overcome by an appropriate choice of keyboard, while the programming should be mainly concerned with reducing and simplifying the control coding necessary to place one element of a formula in proper correlation with another.

problems of character selection best overcome by an appropriate choice of keyboard

December 1969 Printing Trades Journal 33

"WHAT WE LEARNED in 16 YEARS of PHOTOCOMPOSING"*

by Howard King, part owner of the American firm Graphic Services Inc.

My 16 years' experience as part owner of Graphic Services Inc., of York, Pennsylvania. It has been said that we operate the largest photocomposition plant in the world.

Now for the very first time, we are hearing predictions made that hot metal will be almost a lost art by 1975.

First phototypesetting machine was placed on view at the 1950 Graphic Arts Show in Chicago.

Strange as it may seem, up until the year 1968, comparatively few plant owners ventured into photocomposition. Why have so many plant owners become vitally interested all of a sudden? ... until 1945 was the costliest and the slowest ... soon it became the fastest and the most economical of the three processes - ... more books are being printed today by lithography than by letterpress and, because of the expanding phototypesetting industry, this trend can be expected to continue.

photocomposition ... until 1945 was the costliest and the slowest ... soon it became the fastest and the most economical of the three processes

Another reason, perhaps, for the rush to purchase photocomposition equipment is the predictions of some experts, both in and out of our industry. They forecast the need for unprecedented quantities of printing on the part of their clients. Their predictions are based on the graphic arts industry playing the leading role in the exploding 'knowledge industry.'

Some experts, both in and out of our industry forecast the need for unprecedented quantities of printing on the part of their clients.
graphic arts industry playing leading role in the exploding 'knowledge industry.'

First, the quality we must maintain daily to satisfy our customers and the final results we secure from our present equipment, are unobtainable from hot metal because of the flexibility of our photographic process. A perfect example of this is the 'repro proof.' None can match the quality of a negative or positive you would receive from us.

We work strictly with film, and not with paper positives. The film coming from our typesetting equipment in galley form is first put through one of several LogEtronics processors, after which it is run through a Potdevin waxing machine.

Because of the wax back we place on all pieces of film, we have been able to go back to our original pasted-up positives as much as seven years later and make corrections in pages without any noticeable change in the quality. This is particularly important to those book publishers who want to revise some of their important titles every few years.

We also feel that those publishers confronted with large amounts of tabular composition will benefit greatly in having this type of work done by our systems. Tabular composition is set on our Fototronic equipment and we guarantee perfect alignment of columnar material and extreme high quality at a price that is on a par with if not better than, any hot metal system. But, may I stress, we are not a cheap house, because quality is expected of us daily.

---

*Based on an address given by Mr. King at this year's anniversary convention of the International Association of Printing Housecraftsmen Inc.

There are those in the composition business who have the feeling that corrections in phototypesetting is the real problem. We insert corrections into galleys or pages according to the accepted techniques advanced many years ago by the Harris-Intertype Corporation.

The difference, and the reason we are able to keep corrections costs at about the same as in hot metal, is because our six correction room staff are carefully trained, competent and experienced. ...

When you realize that we have 40 persons setting type and only six making the corrections, then surely corrections are not a serious problem as some may think.

The output from our Fototronics is, of course, in the form of film positives.

The value of the computer is two-fold. In the first case it increases keyboard speeds and therefore raises productivity by 20-30 percent, and in the second it increases accuracy.

As to the economics of the computer system which we installed in September 1967, we feel it began paying its own way two months after.

Where do we go from here? you might ask. Should we be thinking of a CRT machine or would we be better off working on additional programmes for our computer. ... or the merging of magnetic tape, or retrieval systems, or printout devices for the publishers? Or perhaps we should be thinking of the impact of the consumer's involvement in the typographic production process, or a page make-up system, or data transmission? We are of course, actively working on some of these problems now.

We must also recognize that one of the prime movers of the avalanche of change in the graphic arts is a relatively new breed to the industry - electronics and data processing technologists and computer-oriented management. This group has been the nucleus which has shaken the very foundations of printing.

For example, a few months ago a publishing company technologist reported on a recent study he made of electronic editing and composition. He forecast writing and transcription on magnetic tape directly from typewriter keyboards on a larger scale within a year or two. (It is possible to do this now, but we feel it is still too costly, and not always the most practical method.) The writer continued by predicting that cathode ray tube display editing equipment will be available this year and that there will be ample cathode ray tube typesetting equipment available in two or three years, as well as long-distance data transmission at much lower rates within 3-5 years.

Tabular composition is set on our Fototronic equipment at a price that is on a par with, if not better than, any hot metal system.

We insert corrections into galleys or pages according to the accepted techniques.

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Forecast:
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Cathode ray tube typesetting equipment available in two or three years, as well as long-distance data transmission at much lower rates within 3-5 years.

The technology this writer refers to is not the simple computerized justification and hyphenation of type lines, the use of second-generation photocomposition machines, or the use of punched paper tape within conventional composing room boundaries. Rather, it is a basic reshaping of the total write-edit-compose process - from the point at which the writer first records his thoughts on manuscript through to finished typeset pages.

It is a basic reshaping of the total write-edit-compose process.

We seem to be moving in this direction quite rapidly and because we are, there is no question, the cost of people is rising and will continue to rise.

The cost of computers is declining and will continue to decline.

The cost of high speed photosetters will decline in years to come.

The cost of computers is declining and will continue to decline. The cost of high speed photosetters will decline in years to come.

These, it seems to me, are reasons enough why more firms are entering the field of photocomposition this year. . . or making an effort to enter it.

III-I-57
Modern Lithography, April 1969

COMPUTERIZED COMPOSITION:
What's the Future for 'Straight Matter?'

by Stanley Rice
Senior Textdesigner for
Harcourt, Brace & World

"Computerized composition has not yet made much of a dent in traditional typesetting of "straight matter," such as book work, although the new computer methods have found significant acceptance in the specialized field of directory-type reference work composition, where the computer's ability to rearrange material provides obvious advantages. . . ."

"Computerized composition has not yet made much of a dent in traditional typesetting of "straight matter," such as book work, . . ."

Henry D. Sedgwick, of Sedgwick Printout Systems, a newly-formed New York Videocomp typesetter, . . . "offers the book publishing industry an opportunity to rationalize its complicated and time-consuming production methods."

Speaking from the publisher's viewpoint, Stanley Rice, a senior textdesigner for Harcourt, Brace & World, argues that his industry must completely reorient its thinking in order to take advantage of the possibilities inherent in computerized composition.

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"A general purpose computer is fundamentally different from any machine we in publishing have ever worked with or designed for," Mr. Rice said in a recent talk to the American Institute of Graphic Arts Book Clinic, "because all its functions have to be defined for it. To code all these specifications completely for a one-time job on a one-code-to-one function basis requires so much function coding that the overall economy is often wiped out in spite of the speed of eventual setting."

". . .
To code all these specifications completely for a one-time job on a one-code-to-one function basis requires so much function coding that the overall economy is often wiped out in spite of the speed of eventual setting.

The obvious solution is to build sets of special instructions concerning the format of a specific editorial structure, which can be stored in the computer memory and activated by insertion of a single format code, Mr. Rice noted. "For example, if we always set an extract with space above it, left indented, reduced size, space below it, this is obviously a repeating problem, even if we do not always set it 9 on 11 Caledonia, one em left indent, six points space above and below it."

". . . what is required of the publishing industry is standardization of formats -- the points at which decisions will have to be made about space, indent, typeface, size, measure, etc. -- with the values of each variable to be decided at a later time, either by a designer or by a standard configuration solution, Mr. Rice said. . . . "There are certainly fewer than 100 common editorial formats that need to be described. They can be specified with respect to their decision points -- and possibly provided with some partial solutions."

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with the values of each variable to be decided at a later time. . . "

"Such action on standardization, however, would accomplish only the very rudimentary goal of adapting to the computer the traditional operations now performed by conventional machines and people," Mr. Rice said. "The pioneers in writing this kind of program have tried to deduce what publishers need from studying our past and present products." Use of computerized systems can make possible wholly new approaches in publishing, he suggested.

"The process of "exploding" or rearranging information "is often considered applicable mainly to catalogs. It certainly does apply nicely to catalogs, but it is best thought of as a more general process, with other potential uses," he said.

"The time is perhaps not too far distant when we shall want to plan that all important material that is to be keyboarded for typesetting should have a machine-readable result that can be computer processed and stored; . . . and conversely that all likely data that is to be computer processed should also be planned so that it can be typeset if desirable. This would require that points in the material at which a decision may later be necessary must be "flagged" with appropriate codes inserted during the keyboarding," Mr. Rice said.

"While up-dating of a text is the most obvious use for the "exploding" process," Mr. Rice said, "there are a variety of other possibilities, such as creating several versions of the same work by abridgement or by simplification of language through word or phrase substitution. . . ."

"A text that is "automatically revisable and transformable along planned lines would allow regional and minority publishing" with little penalty in composition cost," Mr. Rice said.

"None of these possibilities executes itself; they all depend on imaginative planning ahead, careful indexing and correct coding. These things will not be simple; but neither is it simple to do things over and over by hand. The re-composing of the building blocks of information is one aspect of computerized composition which the academic community is finding to be of the greatest interest and potential, and which is now becoming the raw material of publishing."

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The re-composing of the building blocks of information. . . of the greatest interest and potential, . . . now becoming the raw material of publishing."

Printing Equipment & Materials, Sept. 1969

DON'T LET US KID OURSELVES ABOUT COMPUTERS

by R. F. Griffin, Muirhead Limited

... the name electronic brain ...

... it was an entirely false description.

The "electronic moron" might, indeed, be a better name.' It is a moron which does precisely what it is told - and fast. ...

The computer is many things: ...

But it cannot think. It cannot create. It needs man as a team-mate. And it will ever be thus.

One cannot escape the fact that all the functions that have ever been listed as being the forte of the computer involve logic. From a typesetting point of view, this could be disastrous. Because typesetting is concerned with language, and language has evolved with hardly a logical fibre to its make up.

Hyphenation is a case in point ... hyphenating after "THE" is allowable where this is the first syllable of a word. This would be fine in the case of "theodolite", "theorem" and "theosophy" - but what about "therapist"?

...

Choose a computer which is designed to handle just those parts of the typesetting operation that electronics is best fitted to handle, but which leaves the remainder firmly in the hands (or rather the head) of the compositor.

This narrows the field down very considerably for it is tantamount to saying that you should choose a computer which is purpose-designed for the typesetting job.

It is perhaps unbelievable to anyone outside the computer industry that such purpose-made equipment should be very considerably cheaper than an "off-the-peg" machine. But this, in fact, is so. Suppose we discount the original purchase price of a general-purpose computer - hard though it may be to shrug off such an astronomical figure - and think purely of the "software" (programming) needed for each separate typesetting task it is to be set to perform. The cost of each general-purpose computer program - for say setting one journal - could cost up to 50% of the price of a complete purpose-designed typesetting computer with built-in capabilities to handle as many jobs as you care to give it.

Suppose we think purely of the "software" needed for each separate typesetting task it is to be set to perform. The cost of each general-purpose computer program could cost up to 50% of the price of a complete purpose-designed typesetting computer.

The Muset K-380-B is an example of purpose designed typesetting computery which illustrates these points. It is low-cost electronic equipment for the automatic production of high quality type composition from unjustified TTS tape. It has built-in facilities for handling all normal composition functions automatically, thus obviating the need for programming and the purchase of expensive software.

The operator merely taps out his text to produce an unjustified tape which is fed to Muset. The equipment then automatically produces a fully justified tape in which typeface, type size, line measure and setting styles are as specified by the operator.

By means of input tapereader-alloters the outputs from up to sixteen remotely sited keyboards can

By means of input tapereader-alloters the outputs from up

be routed to a single Muset. A westrex punch operating from the computer's output produces the final fully justified 6 level TTS tape at a rate of 110 characters per second - and this enables no less than fifteen line casters to be operated at the rate of twelve lines per minute.

These are the operations that electronics can perform so superbly well - all involving logical rules, all performed at high speed.

But the spelling of the words, the punctuation, the hyphenation. These are strictly for the operator.

...

Versatility

One of the printers who have installed Muset and have found that it solves one of their most troublesome problems is Buxton Press Ltd. of Buxton, Derbyshire. It is mainly used for setting several monthly magazines, including DESIGN ELECTRONICS, COMMERCIAL VEHICLES, CARPETS AND TEXTILES.

They cover a pretty wide range of sizes and type faces and illustrate the ability of Muset to handle easily and quickly many changes of typeface, type size and line measure.

This small installation - it occupies less than 4½ square feet of table-top - has by itself almost doubled this company's capacity for the composing room. Without any addition to the TTS installation it now serves the new lithographic side of the business as well as the letterpress plant for which it was originally equipped.

Many points are abundantly clear from the industry's experience of computers to date.

Firstly, they help human operators but do not replace them. Secondly, they are extremely efficient at doing what they are designed to do - those operations that are governed by immutable logic. Thirdly, they can be an extremely economical way of getting first class setting quickly - provided they are designed for the typesetting job.

Bearing all these points in mind, any printer with a TTS system or who is contemplating installing one can be sure that this application of electronics is one that will almost certainly carry him to extra profitability.

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1. they help human operators but do not replace them;
2. they are extremely efficient at what they are designed to do;
3. they can be an extremely economical way of getting first class setting quickly

Pira Report, April 1968 Project PR 20

AN ANALYSIS OF COMPUTER TYPESETTING SYSTEMS IN THE UK

D. L. Cooper and C. D. Nield

Preface

Why this survey

In the rapid and far reaching expansion of computer technology, it was inevitable that it made its impact on the world of print and in a short space of time, 'computer-typesetting' (or one of its variants) has become part of many printers' day-to-day language. There are places where 'ems and ens' are being replaced by 'bits and binaries' and the language and methods have already necessitated the creation of computer-typesetting specialists.

. . . rapid and far reaching expansion of computer technology . . . its impact on the world of print.

It is a new and expensive field and there is already a multiplicity of equipment and application which pose problems to the printer who feels he ought to be in on the new technology. Rapid development likewise causes concern to those who have already taken the plunge.

. . . already a multiplicity of equipment. . . which pose problems to the printer who feels he ought to be in.

For some time it has been considered that Pira ought to be in a position to give broad advice on this subject to the industry--to be in fact a bridge between the computer and the printer. . .

Introduction

James P. Turner

When the merger between PATRA and BP & BIRA took place in June 1967, it became possible for the new organization, Pira, to consider its role in the field of computer typesetting. Two complementary interests, namely the Computer Section and the newly formed Composition Section, were brought together to take up this problem.

It was decided, with the approval of the Pringing Divisional Committee, to initiate a survey into the use of computers in typesetting in the UK. A project panel under the chairmanship of Mr. J. P. Turner, Assistant Controller of HMSO, was set up to guide the team.

a survey into the use of computers in typesetting in the UK

This report presents the results of the survey. It has been a deliberate decision to present a report which discusses the reasons that have motivated printers in installing computers for typesetting and problems that have been encountered in systems design.

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Section 1

PLANNING FOR A COMPUTER SYSTEM

1. The basis for computer involvement
   In most instances the basic reason has been to reduce costs, but the justification in economic terms depends on individual circumstances. Financial incentives include the Government grant for computers, which varies from 25% to 45% depending on whether the firm is in a development area.

In most instances the basic reason has been to reduce costs

2. Considerations in system design
   The following considerations have been taken into account in the installations visited.

a. **Keyboard/computer relationship.**

One of the first considerations, though not necessarily the most important, concerns the interface between operator and computer. There are basically three methods of input:

i. On-line.
ii. Semi-on-line.
iii. Off-line.

Both on-line and off-line systems may be designed which give most emphasis to higher productivity, however, operatives with a particular temperament are required for systems from which all intellectual activity has been removed. Most firms visited recognized this fact and designed their system so that operatives participated in it more than they would need to if higher productivity was the only goal.

Operatives with a particular temperament are required for systems from which all intellectual activity has been removed.

In one instance at least, where maximum keystrokes had been the goal, some of the operators had asked to be returned to their former activities.

It is unlikely at present that on-line input keyboards can be justified financially for non-newspaper work. The preparation of copy on keyboards is likely to be only a small proportion of the total work load of the computer.

b. Associated applications

Another consideration which will affect the design of the system depends on whether the computer is to be used for more than setting lines of type.

In non newspaper systems, additional benefits will accrue from computer systems that handle files of information which are updated from time to time. Further benefits will also come from efficient systems for processing authors' corrections and carrying out editing functions such as page make-up. Such editorial work is carried out on the information stored on magnetic tape. Typesetting does not take place until the copy is correct . . .

. . . benefits will accrue from computer systems that handle files of information which are updated from time to time.

Such editorial work is carried out on the information stored on magnetic tape. Typesetting does not take place until the copy is correct . . .

d. Output medium

The question of whether output should be to hot metal or phototypesetter is not always within the terms of reference of the system design. Examples of both types of system have been seen. The output medium will, however, have an impact on the system for copy preparation, proofing, reading, editing, make-up and printing.

In a situation where the output is to hot metal, a line-printer proof with a limited character set may be acceptable internally but it is not likely to be acceptable to the customer. A chain printer such as that installed at Garden City Press, having as it does a much wider character set, may provide an acceptable alternative.

e. Development

f. Reliability

g. System specification
A number of considerations should be taken into account, the most important of which are:

i. The system design presented as a specification to manufacturers should be fully documented. This should include not only flow charts of each section of the system but details of the amount and type of copy and its frequency and rate of process. In return the printer should expect a similar standard of documentation from the manufacturer. This should include details of how the system design is to be implemented and specifications of all programs to be supplied. It has been evident from our discussions that manufacturers are loath to disclose certain parts of their programs, especially those associated with the logic behind hyphenation routines. Although no doubt a case can be made out for secrecy in these circumstances, it can cause serious inconvenience to printers who wish themselves to modify a program to take into account their own particular circumstances.

It has been evident from our discussions that manufacturers loath to disclose certain parts of their programs.

h. System development and staffing
The range of tasks with which the computer will have to deal will almost certainly increase with time. The printer, having assured himself that the range of equipment supplied by the manufacturer will cope with these extra demands, must further decide how the necessary systems design and programming can be accomplished . . . Although training of existing staff to operate the computer does not seem to have presented any difficulties, the problem of retraining keyboard operators has to be faced. This is recognized to be a very important point but does not come within the terms of reference of this report.

the problem of retraining keyboard operators has to be faced. This is recognized to be very important point but does not come within the terms of reference of this report.

Section II
CONCLUSIONS

a. Increase in key depressions per operator, per hour. Those who have set this as a prime objective have, in general, not yet achieved their target. The main reason is that not all operators are able to resign themselves for a full shift to an activity from which all intellectual content has been removed.

Another reason is that most of these schemes have involved the retraining of linotype operators, many of whom have not yet reached their potential speed on the new keyboard. Apart from the cost aspect, an increase in the rate of key depressions may be important where labour is in short supply . . .

c. Financial savings in areas other than setting lines of type.
The financial benefits to be obtained from these associated activities cannot at present be assessed directly, as all such systems seen are still in the development stage . . .
For non newspapers the choice of work which can be profitably produced by computer systems must be carefully considered. The decision to choose a computer system must reflect not only the capability of the firm but also the presence of a suitable market large enough to utilize the computer to its best advantage. It would be futile to enter into the computer typesetting field without making a detailed cost comparison . . .
Insofar as the system design is concerned, the main conclusion from the survey has been the degree to which printers have been willing to accept from computer manufacturers systems and program packages without careful analysis of their particular situation. The computer and the printing process have a unique relationship, in that the computer replaces part of the process itself rather than being an adjunct to it. For this reason it is even more important that the role the computer can play should be most carefully considered. Its relationship to the other parts of the process are likely to differ from one firm to another and thus the computer's versatility can best be used in a bespoke system. It is not surprising that this situation has arisen, considering the lack of disinterested advice available. . .
Few printers have staff qualified to develop computer systems and programs in step with the development of the business as a whole. The degree to which this is necessary will depend on the particular circumstances. In some cases support could be supplied by Pira or other independent consultants who will be able to implement these developments.

Most of these schemes have involved the retraining of linotype operators, many of whom have not yet reached their potential speed on the new keyboard.

For non newspapers the choice of work which can be profitably produced by computer systems must be carefully considered.

The computer and the printing process have a unique relationship, in that the computer replaces part of the process itself rather than being an adjunct to it. . . the role the computer can play should be most carefully considered. Its relationship to other parts of the process are likely to differ from one firm to another and thus the computer's versatility can best be used in a bespoke system.

Printing Equipment & Materials, September 1969

EASTERN EUROPEAN PRINTING EQUIPMENT

PEM reports on
Inpolygraphmash 69

For the visitor to Sokolniki Park, Moscow, in July it was difficult to realize that this was the first international printing exhibition ever held in Russia. The participation of around 700 companies and organizations from 20 countries made Inpolygraphmash a major event by any standards.

Comments on the attractive British pavillion are made elsewhere in this issue, and most of the Western European equipment seen at Moscow will be shown in Milan and featured in GEC preview of PEM in October. This review, therefore, concentrates on products from Eastern Europe which are not widely known in Britain.

text layouts as shown in draft

Statistics issued by the Soviet authorities reveal that 8,000 newspapers and more than 4,300 magazines with a total circulation of 250,000,000 are published in the USSR, as is every fourth book title in the world. With figures such as these it is perhaps not surprising that generally there appears to have been rather more attention paid to the quantity than to the quality of Soviet equipment, and that some of it is four or five years behind the west, technically speaking.

Statistics reveal that 4,300
magazines are published in
the USSR, as is
every fourth bock title in the worl

These are, it must be stressed, generalizations, and the overall impression is one of amazement at the very wide range produced by an industry that did not come into being until 1931, with the first flat-bed press of Russian make, and one year later with a linecaster. Nowadays some 2,000 composing machines alone are produced annually.

Nowadays some 2,000 composing machines alone are produced annually.

Composing

It was in the extensive display of Russian composing equipment that was to be found one of the few novelties at the exhibition, plastic type for hand setting. The equipment is similar to that for casting individual metal characters for founders type, but with the pot containing granulated plastic heated to a temperature of 200°C in 45 minutes and injection moulded by a piston. Body type of 6 to 12 point size can be cast at a rate of 24 to 40 characters a minute. To quote from the Russian literature, "the process for manufacturing type from AT plastic compound satisfies the strictest requirements towards the precision of casting and the quality of typeface." It adds that the cost is reduced, the life of the type increased fourfold, weight reduced to a tenth, and working conditions improved. The material, which can be recovered and remelted just as with metal, has a specific impact strength of 18-20kg/cm^2, flexible strength of 1300-1400kg/cm^2, heat resistance of 72°C, and is resistant to benzene and kerosene, PEM awaits world reaction to this development with some interest.

plastic type for hand setting

granulated plastic heated and
injection moulled by a piston. . .
cast at a rate of 24 to 40
characters a minute

the cost is reduced,
the life of the type increased
fourfold,
weight reduced to a tenth,. . .

There were at least eight different models of Russian-made linecaster on show at Moscow, some of them already available in Britain. Single-type hot metal casters, their equivalent in film, display, slug and strip casters were also in evidence. There appeared to be a lack of computerization in typesetting, with the exception of a photosetter with a capacity of 540 cps and two keyboard systems. The latter are for the preparation of 6-level and 7-level perforated tape for hot metal or filmsetting machines. Both have hard copy facilities, automatic justification, runarounds, etc., and provision for merging of corrections to produce a clean end product.

It is interesting to note the emphasis placed in the descriptive literature on the fact that text preparation and page makeup are performed under the control of the editor in the publishing house.

text preparation and page makeup are performed under the control of the editor in the publishing house

Processing

In view of the fact that Russia lags some distance behind the west in the development and use of plastics, it is rather surprising that one of the novelties in the processing section should, as in the composing display feature a device utilizing plastics. The equipment in question is a casting unit for the production of polyetherurethane flexographic printing plates. Accuracies of +0.05mm and -0.07mm are claimed, obviating the need for shaving. Casting time is 15 to 20 minutes at 110°C. . . .

Russian printing is very predominantly letterpress at the moment, and the lithoprocessing equipment was largely conspicuous by its absence. So far as could be ascertained, presensitized plates are unknown in the USSR, although the success of Rotaprint machines in that market and the interest shown on the SD Syndicate lithoplate stand are certain to have an effect in that respect at least. Although the unit itself was not demonstrated, details were provided of a mechanized production line for the processing of diazo-coated bimetal plates of various types to a maximum of 2.52m^2 surface area at an output rate of 18 a minute.

Computer World, September 20, 1970

Study Predicts
PHOTOTYPESETTING to RISE 300 percent
in Next Five Years

Los Altos, California --

Phototypesetting is expected to mushroom 300% in the next five years to become a $150 million a year business by 1975, according to a new research study prepared by Creative Strategies, Inc. (CSI).

CSI, a high technology research and consulting firm, reports in depth on four new segments in the phototypesetting market which, in the next five years, are expected to capture 65% of the market.

The fastest growing segment, low-priced text oriented machines, should grow at a compound annual rate of 43%, the study predicts.

The medium-priced ($100,00) electronic CRT devices can anticipate a compound annual growth rate of 38%.

The extremely fast, high-priced CRT machines (over $300.00) are expected to reach market saturation and experience declining sales after 1973.

This is partly attributable to their high-speed capability -- eight CRT machines, working a single shift, could typeset all the books published annually in the U. S.

Creative Strategies, Inc.
(CSI)

Phototypesetting (by 1975) to become a $150 million a year business.

to capture 65% of market

low-priced text oriented machines annual growth -- 43%

medium-priced CRT devices anticipated growth rate -- 38%

high-priced CRT machines expected market saturation after 1973

ETD/PD/0086

ANL
1970

AVAILABILITY OF COMPOSITOR'S TAPES FOR BRAILLE PRODUCTION

1. Tape material(s) Format(s) used:[1] Code(s)			
2. System(s) used[2]			
3. How "clean" are tapes? Are all corrections carried back to data base? Are tapes complete?	a) Average	b) Best ~10%	c) Least 10%
4. Could you reformat tapes to a specified code and eliminate machine commands?[3]	a) Would reformat and "clean up"	b) ~price per title $	
5. How long are tapes kept after completion?	a) Average	b) clean tapes	c) "Raw" tapes
6. Given Publisher's authorization would you release tapes or tape copies for braille production exclusively (non for profit)	a) Free of charge	b) At ~$ per copy	
7. What is the "scope" of texts produced with compositor's tapes (titles per year)	a) Straight English	b) Scientific & college	c) Elementary & High School
8. What do you project to be the usage of compositor's tape in % of all type generation by 1980?	a) Straight English %	b) Scientific & college %	c) Elementary & High School %

III-1-68

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[1] For example 6 channel, punched paper, TTS, or 1/2" Magnetic 7 track 556 bits per inch BCD etc.

[2] For example RCA 301 CRT System + XYZ Computer & IBM MTST editing facility etc.

[3] The reformatted text would thus be equivalent to a clean edited manuscript in the code & format specified (say 556 bpi/BCD).

IBM 1403 PRINTER MODIFICATIONS FOR COMPUTERIZED BRAILLE OUTPUT

by

Elliot L. Kolsto, ANL Report 7812, July 1971

ABSTRACT

This report describes a standardized process for producing Braille computer output on an IBM 1403 line printer. A specific length of resilient rubber is stretched in front of the printer hammers to serve as a cushion for the penetration of characters into the paper. Rows of periods are printed, creating Braille characters on the reverse side of the paper.

I. DEVELOPMENT OF THE TECHNIQUE

In 1969 we began working with IBM's utility program* for the production of Braille on the 1401 line printer. IBM's suggestion of taping garter elastic across the hammers was tried, but produced results that were less than satisfactory. Several different types of cushions were tried, including multiple layers of paper and different thicknesses and layers of natural rubber, but we were unable to produce a good quality Braille with any degree of consistency. During this experimentation, removal of any ink buildup around the period on the print chain resulted in far more consistent quality.

The cushioning materials we found to be best suited to our needs were single strips of neoprene or polyurethane stretched to a specific tension in front of the printer hammers. Length variations of as little as 1/2 in. caused problems with the quality. If the rubber was too loose the strip would slip out of position when a page was ejected; if it was too tight, the rubber was pierced after only a few runs. Another problem was that the cushions often came loose during a run, causing a loss of both time and Braille output.

We then began to use IBM brackets for holding the rubber in place. However, the brackets did not solve all the problems. The rubber still had to be taped to the brackets or pierced over the end of the hook-shaped brackets. There was also the problem of relating to computer operations personnel exactly how tightly the rubber should be stretched.

We therefore decided to permanently attach a pair of clips to a rubber strip of the proper length and mount this on the IBM brackets. This solved the problem of installing the cushion with consistently proper tension. The clips also made positioning of the neoprene strip both easier and faster and eliminated the problem of rubber slippage during a run.

II. DESCRIPTION OF THE CUSHIONING STRIP

The strip we are presently using is a neoprene strip 9-1/2 in. long, 5/16 in. wide, and 1/32 in. thick. The overall length is slightly shorter after the strip is attached to the clips (Fig. 1a). The clips are made from electrical wire holddowns by bending the curved part of the holddown to secure a doubled end of rubber approximately 1/4 in. long within the crimp of the metal (Fig. 1b).

III. PROCEDURE FOR PRODUCING BRAILLE OUTPUT

A pair of the hook-like brackets that IBM offers must be installed on the line printer so that the strip can be mounted. The carriage control tape used is made for eight lines per inch and 80 lines per page. Printers that are in heavy use will probably have an ink buildup around the period. This buildup can be quickly removed by opening the print gate and swinging the ribbon shield out of the way to expose both ends of the print chain (Fig. 2). The chain should be advanced until a period slug appears at a convenient position. A dry cotton swab can then be used to remove the ink residue; no ink residue should be allowed to fall between the slugs of the chain. The residue can be wiped from each period. The number of period slugs will

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**Contributed Program Library*, IBM Operating System/360 Braille Utility Program 360D-01.0.005, p. 8.

vary slightly depending on the type of chain (PN, QN, etc.) in the printer. After the cleaning is completed, the ribbon shield can be swung back into position, leaving the print gate open.

The paper should then be removed from in front of the hammers and the Braille clips hooked onto the IBM hooks as shown in Fig. 3. Caution: If the clips are not positioned

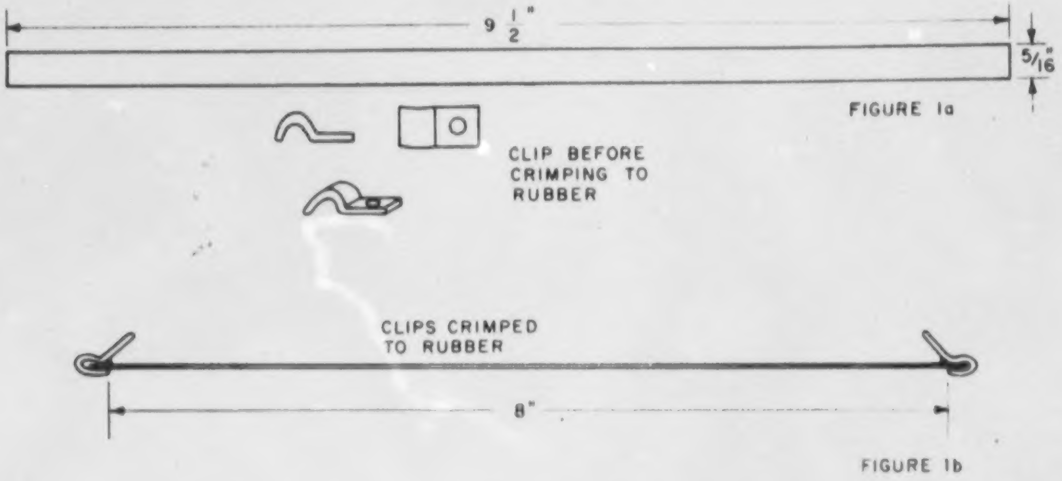
9 1/2"
5/16"
FIGURE 1a
CLIP BEFORE CRIMPING TO RUBBER
CLIPS CRIMPED TO RUBBER
8"
FIGURE 1b

Fig. 1. Method of Attaching Holddown Clips to Neoprene Cushioning Strip

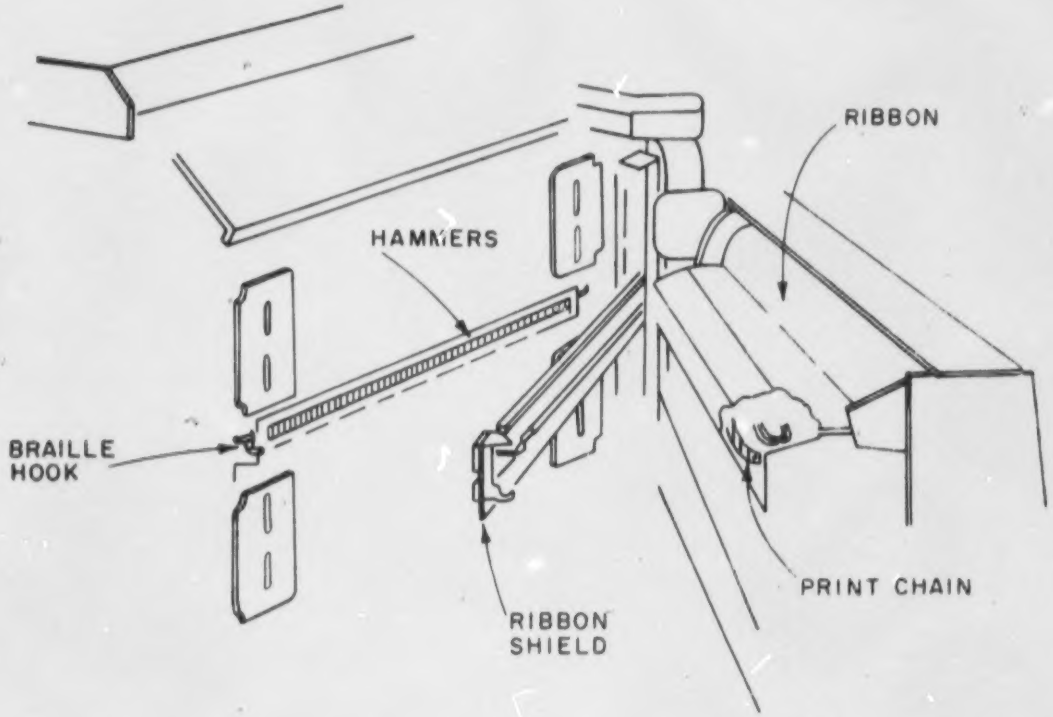
RIBBON
HAMMERS
BRAILLE HOOK
PRINT CHAIN
RIBBON SHIELD

Fig. 2. View of Exposed Print Chain

correctly, they will come in contact with the print chain when the gate is closed.

Next the paper can be replaced and the print gate closed. The form's thickness should be set for the thinnest setting (0.003 on an IBM 1403), and the print density control set to the heaviest setting ("A" on the 1403).

The printer is now ready to produce Braille output. The most time-consuming part of the procedure is the cleaning of the periods, but with practice the entire printer setup will take less than five minutes.

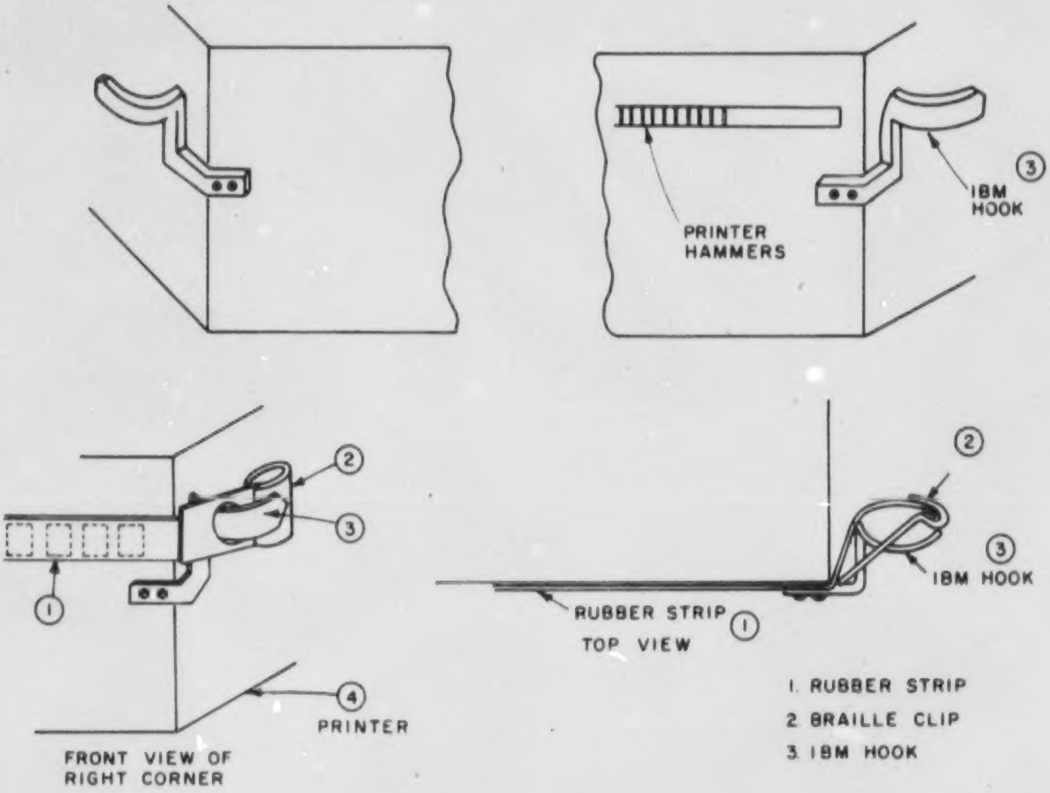
PRINTER
HAMMERS
IBM
HOOK
③
②
③
①
④
PRINTER
FRONT VIEW OF
RIGHT CORNER
②
③
IBM HOOK
RUBBER STRIP ①
TOP VIEW
1. RUBBER STRIP
2. BRAILLE CLIP
3. IBM HOOK

Fig. 3. Method of Attaching Cushioning Strip to IBM Braille Hooks

ACKNOWLEDGMENTS

My thanks to Lois Leffler, Arnold Grunwald, and Peter Grunwald for their assistance and advice in the development of this Braille-producing technique.

IV. LETTERS AND AWARDS IN RECOGNITION OF THE DEVELOPMENT OF THE ARGONNE BRAILLE MACHINE

United States Patent

[11] **3,624,772**

[72] Inventor **Arnold P. Grunwald**
Chicago, Ill.
[21] Appl. No. **874,734**
[22] Filed **Nov. 7, 1969**
[45] Patented **Nov. 30, 1971**
[73] Assignee **The United States of America as represented by the United States Atomic Energy Commission**

[54] READING AND WRITING MACHINE USING RAISED PATTERNS

6 Claims, 7 Drawing Figs.

[52] **U.S. Cl.** 197/6.1, 35/35 A, 178/17 A, 178/30, 235/61.12, 242/192, 242/200
[51] **Int. Cl.** B41j 3/32, G09b 21/00
[50] **Field of Search** 197/6.1, 19, 35/35; 178/17 A, 30; 235/61.12; 242/192, 200

[56] **References Cited**

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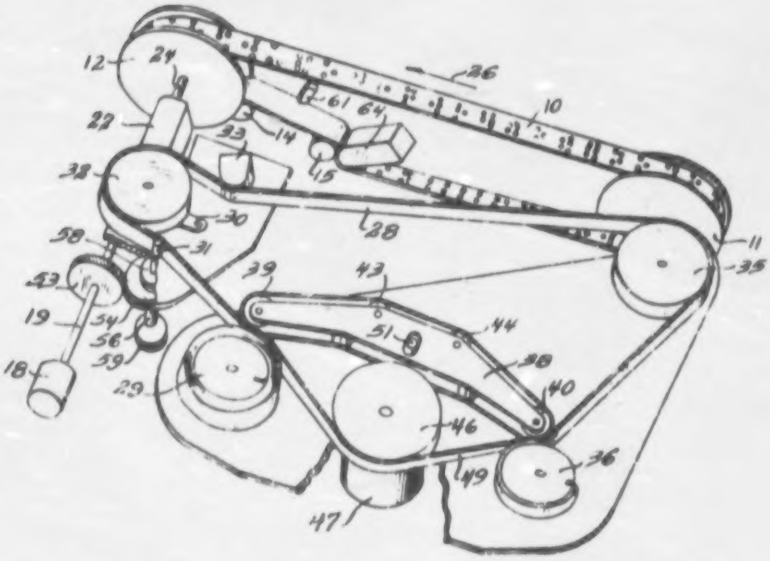
Primary Examiner—Robert E. Pulfrey
Assistant Examiner—R. T. Rader
Attorney—Roland A. Anderson

ABSTRACT: A reading and writing machine which uses raised patterns to convey information includes a reading belt upon which the patterns are formed and a tape which stores the information. The tape is divided into a plurality of different information portions which the machine can selectively read. Provision is made for writing on selected portions of the tape on blank tape. A simple tape drive mechanism is provided which prevents slack in the tape yet does not require a variable speed drive. The reading belt is formed of plastic with bubbles having two stable positions molded therein.

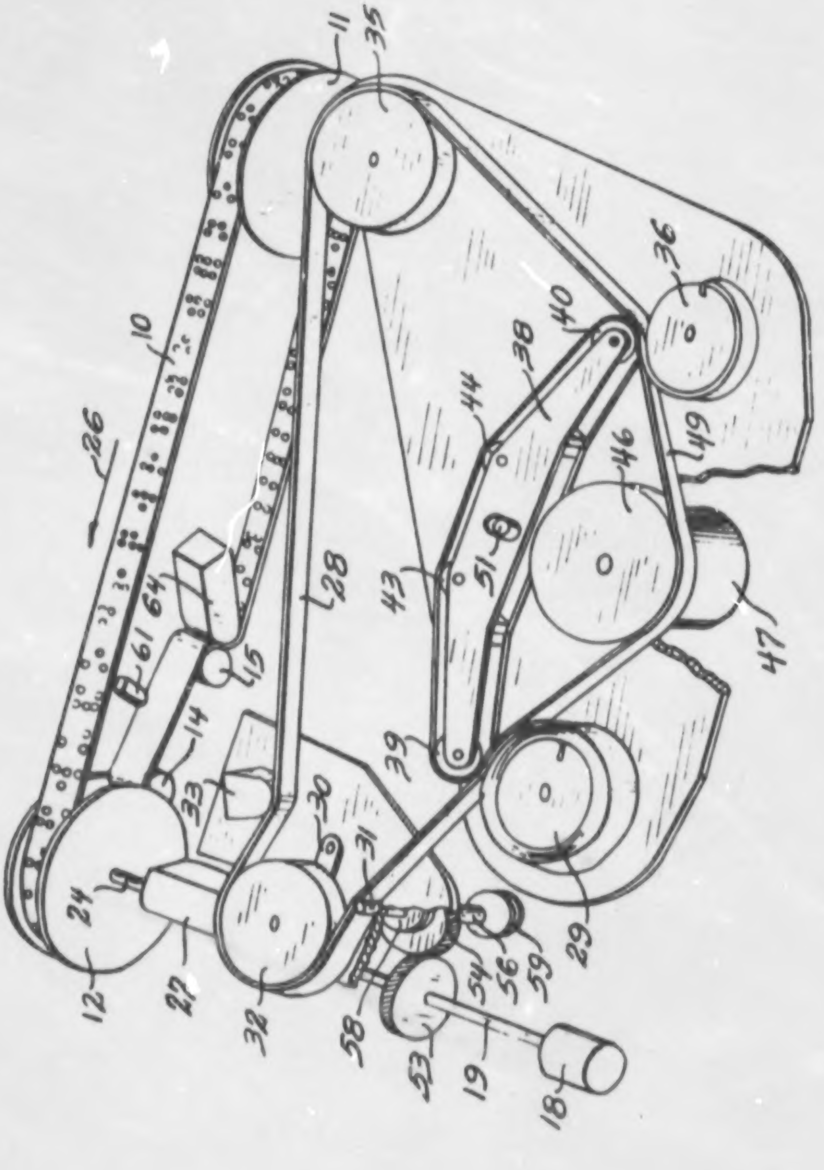


IV-A-2

PATENTED NOV 30 1971

3,624,772

SHEET 1 OF 4



11
35
10
26
36
40
38
44
49
46
28
64
61
51
43
15
47
14
39
33
30
31
29
24
22
12
32
58
54
56
59
53
19
18

Fig-1

Inventor
Arnold P. Grunwald

Attorney

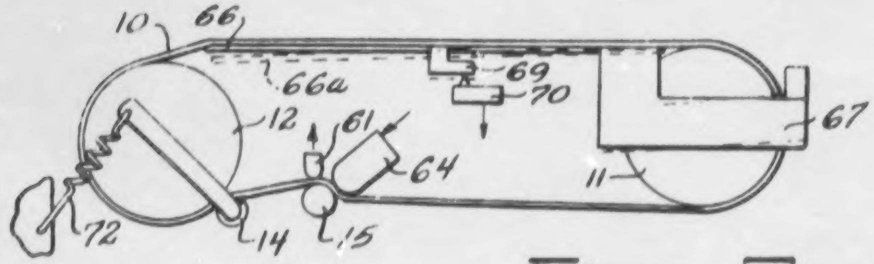

10
66
66a
69
70
12
61
64
67
11
72
14
15

Fig-2

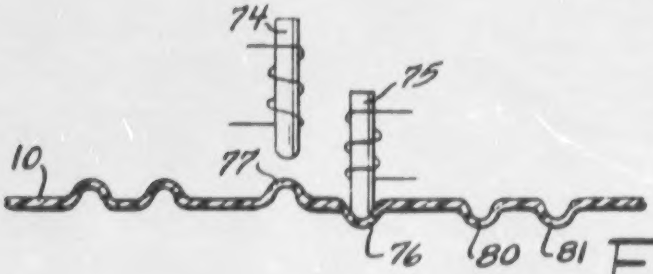

74
75
10
77
76
80
81

Fig-3

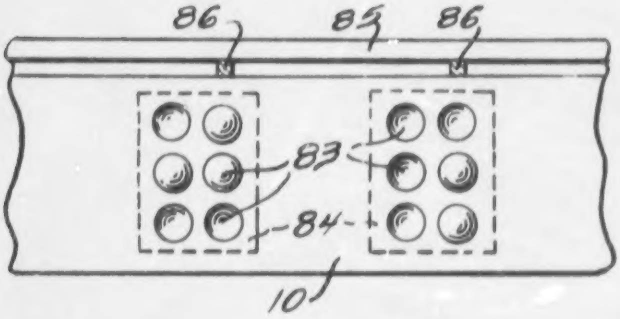

86
85
86
83
84
10

Fig-4

	(BLANK) SPACE	ZERO	ONE	BP
TRACK A	0	0	1	1
TRACK B	0	1	0	1

Fig-6

Inventor
Arnold P. Grunwald
Attorney

PATENTED NOV 30 1971

SHEET 3 OF 4

3,624,772

IV-A-4

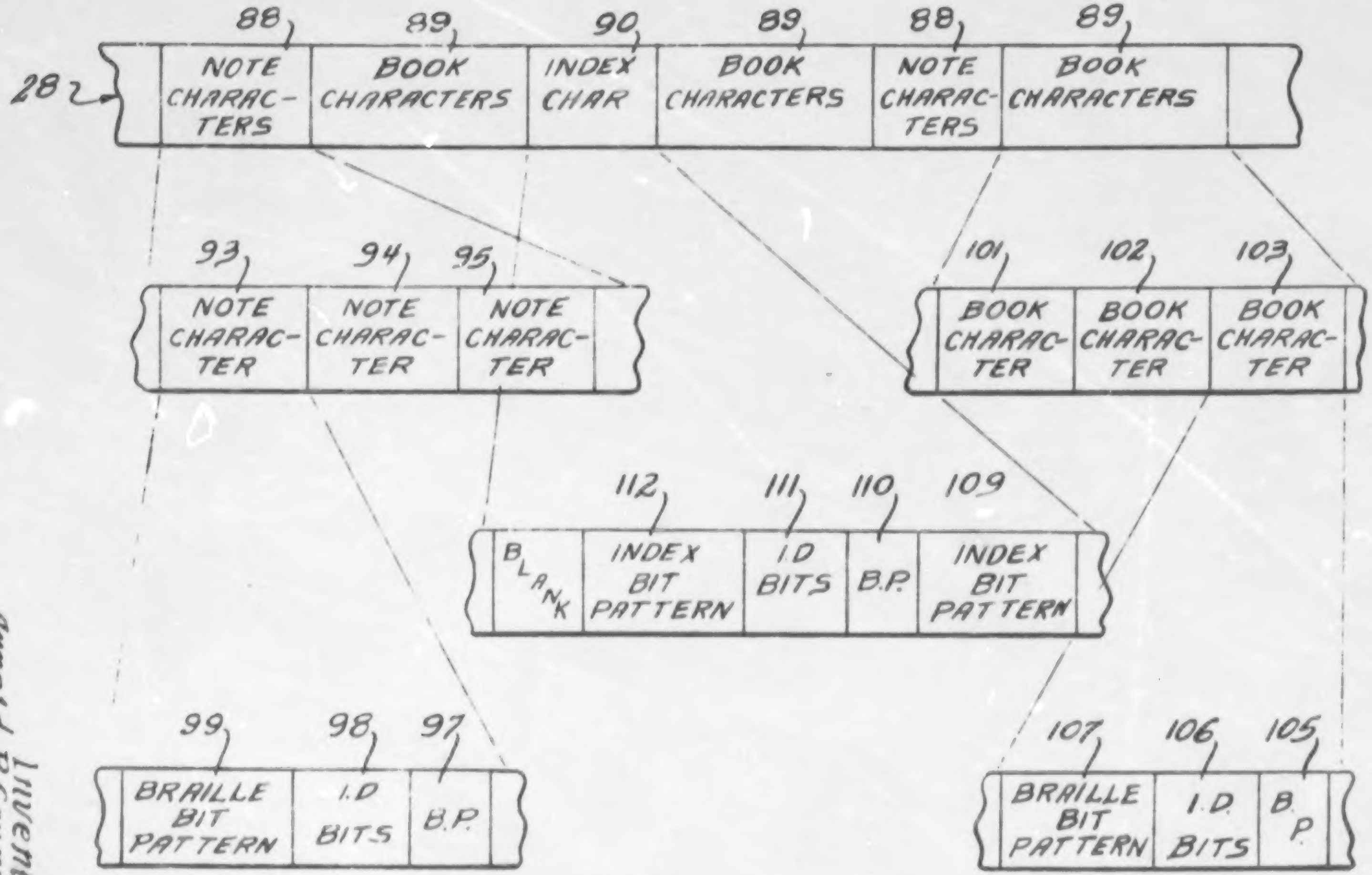

28
88
NOTE CHARACTERS
89
BOOK CHARACTERS
90
INDEX CHAR
89
BOOK CHARACTERS
88
NOTE CHARACTERS
89
BOOK CHARACTERS
93
NOTE CHARACTER
94
NOTE CHARACTER
95
NOTE CHARACTER
101
BOOK CHARACTER
102
BOOK CHARACTER
103
BOOK CHARACTER
112
111
110
109
BLANK
INDEX BIT PATTERN
I.D BITS
B.P.
INDEX BIT PATTERN
99
98
97
BRAILLE BIT PATTERN
I.D BITS
B.P.
107
106
105
BRAILLE BIT PATTERN
I.D BITS
B.P.

Fig-5

Inventor
Arnold P. Grunwald

Attorney

PATENTED NOV 30 1971

3,624,772

SHEET 4 OF 4

IV-A-5

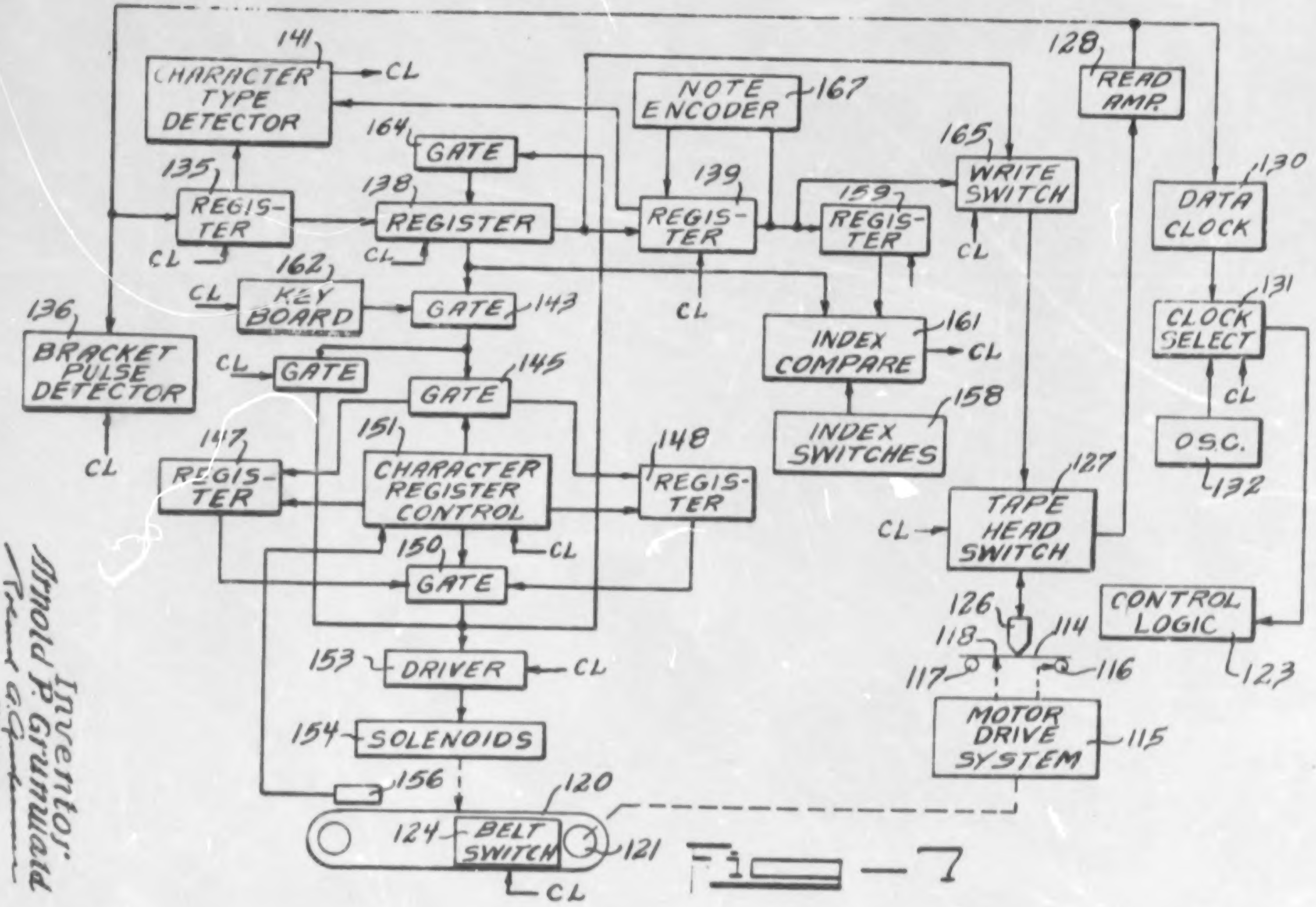

CHARACTER TYPE DETECTOR
141
CL
NOTE ENCODER
167
128
READ AMP.
164
GATE
165
WRITE SWITCH
135
REGISTER
138
REGISTER
139
REGISTER
159
REGISTER
130
DATA CLOCK
CL
162
KEY BOARD
GATE
143
CL
INDEX COMPARE
161
131
CLOCK SELECT
136
BRACKET PULSE DETECTOR
GATE
145
GATE
INDEX SWITCHES
158
OSC.
132
147
REGISTER
151
CHARACTER REGISTER CONTROL
148
REGISTER
127
TAPE HEAD SWITCH
150
GATE
126
118
114
CONTROL LOGIC
123
117
116
153
DRIVER
154
SOLENOIDS
MOTOR DRIVE SYSTEM
115
156
120
124
BELT SWITCH
121

Fig-7

Inventor:
Arnold P. Grunwald

Attorney

READING AND WRITING MACHINE USING RAISED PATTERNS

CONTRACTUAL ORIGIN OF THE INVENTION

The invention described herein was made in the course of, or under, a contract with the UNITED STATES ATOMIC ENERGY COMMISSION.

BACKGROUND OF THE INVENTION

At present there is a large unbalance between the availability of printed and written material to the sighted and to the blind. The blind have access to recorder material primarily through braille writings and sound recordings. While these two media do not conflict but rather complement each other, the sound recordings have certain disadvantages.

Only a small amount of sound recorded material is generally available; thus sound recordings for the blind must be specially prepared by individuals who read aloud from written material that a blind person wants to study. Access to a particular portion of sound recorded material is not convenient. Furthermore, it is known that peripheral stimulation of senses not directly involved is often advantageous in performing work. This is particularly important for a blind reader, whose connection with the outside world is predominantly auditory. When "reading" is done by ear, the auditory peripheral stimulation becomes confusing rather than helpful.

The braille system of reading uses tactile recognition of raised dots on a page to convey information to the reader who perceives the dot patterns in a manner comparable to a sighted reader's seeing letters. The braille pages are relatively easy to index, so there is good random access to the material. Braille writers have also been developed so that the reader can take notes and prepare material for others to read. Braille has the advantage of being able to be read at a very rapid speed not substantially different from the speed commonly achieved in reading ink print material by sighted people. A further advantage is that the braille material can be read at a desired speed, while recordings must be listened to a predetermined speed. A braille passage can be read and reread as desired, while this is not convenient with a recording.

However, braille has a very large drawback in that the braille material is necessarily very voluminous; its bulk is approximately 50 times that required for corresponding ink print material. Furthermore, braille material must be translated from ink print material because there is not a simple (one to one) correlation between the two. Therefore translation, rather than simple substitution of one character for another, is required. The bulky material, together with the need for translating, causes the braille material to be very costly and it is available only in very limited scope.

Modern printing systems have been developed which use tape for setting the printing type. Computer programs have been developed which will translate the print tape into a braille tape at low cost. However, the extremely large bulk of the braille material and the cost of manufacturing a braille book limit the availability of braille material even if these techniques are used.

Certain machines have been developed which will present braille symbols to the reader in response to a tape input. However, these machines have themselves been relatively bulky, inconvenient to use and expensive. While some of these machines have provided an indexing system, this system is of limited value. In addition there is no provision on these machines for writing, and in particular annotating, the material read.

It is therefore an object of this invention to provide and improved reading and writing machine using raised characters and in which the bulk of the material used to store the desired information is extremely small.

Another object of this invention is to provide a reading and writing machine using raised characters and having a reading speed controllable by the operator.

Another object of this invention is to provide a reading and writing machine using raised characters wherein the cost of the reading material is low.

Another object of this invention is to provide a reading and writing machine using raised characters which does not require the operator to learn a new reading skill.

Another object of this invention is to provide a reading and writing machine using raised characters which gives easy and fast random access to any page, subject volume, etc.

Another object of this invention is to provide a reading and writing machine using raised characters which has a writing feature so that the reader can annotate material or write original material.

Another object of this invention is to provide a reading and writing machine using raised characters which is lightweight, portable, easily operated and has low power consumption so that the operator can use it at any desired location.

SUMMARY OF THE INVENTION

In practicing this invention, a machine is provided having a belt upon which raised characters are formed and a magnetic tape having information stored thereon. The machine "reads" the information stored on the tape and from this information develops the patterns of raised characters on the belt. The tape is capable of storing reading material and is indexed so that any desired portion of the tape can be quickly and automatically found. In addition, a portion of the tape may be reserved so that the machine operator can make notes on the tape. The note-making feature of the machine can also be used by the operator to place information on a blank tape which can then be used by another operator in a similar machine.

The drive mechanism for the machine provides a fast forward or fast reverse movement as well as an intermittent or stepping tape transport. The tape is driven directly from the periphery of the tape coils wound on supply velocity without the need for complicated variable rotary speed tape-driving mechanisms.

The belt is a plastic material upon which "bubbles" have been formed in a desired pattern. The "bubbles" are bistable in that they can be pushed to one side or the other side of the belt and will remain in either position. In operation, a portion of the machine sets all of the bubbles so that they are on one side of the belt. A solenoid-actuating mechanism selectively pushes desired ones of the bubbles to the other side of the belt to form the raised characters to be read by the machine operator.

BRIEF DESCRIPTION OF THE DRAWINGS

The invention is shown in the drawings, of which

FIG. 1 is a perspective drawing of the machine,

FIG. 2 is a view of the belt mechanism of the machine,

FIG. 3 is a view of the belt and solenoid actuators,

FIG. 4 illustrates the belt, bubble and magnetic track patterns;

FIG. 5 illustrates the arrangement of information on the magnetic tape,

FIG. 6 shows the code pattern used on the magnetic tape, and

FIG. 7 is a block diagram showing the logic used to control the machine.

DETAILED DESCRIPTION OF THE INVENTION

While the machine described can be used with any system using raised patterns to convey information, it will be described as a machine for reading and writing braille.

Referring to FIG. 1 an endless belt 10 is held by wheels 11, 12, 14 and 15. Wheel 12 is driven by motor 18 through shaft 19, variable speed transmission 22 and shaft 24 so that the belt moves in the direction of the arrow 26. The operator places his hands on belt 10 with the raised braille characters thereon moving under his hand, permitting the operator to read the information stored on the magnetic tape. The speed of the belt 10 is controlled by variable speed control 22.

Magnetic tape 28 is stored on a tape supply reel 29 and is threaded around a capstan 31, pinch wheel 32, past tape head 33 and around idler wheel 35 to tape takeup reel 36.

A tape driving mechanism consists of a idler arm 38 which contains idler wheels 39 and 40 and braking wheels 43 and 44. A drive wheel 46 coupled to drive motor 47 is also provided. A rubber belt 49 extends around drive wheel 46, idler wheel 39, brake wheels 43 and 44 and idler wheel 40. The length of rubber belt 49 is such that it is under tension when it is placed in the position shown. A pivot 51 positions the idler arm 38 and the tension of the rubber belt 48 pulls arm 38 against reels 29 and 36 so that belt 49 hugs the periphery of the magnetic tape on takeup reel 36 and tape supply reel 29.

In operation, motor 47 drives drive wheel 46, moving the rubber belt 49 in a direction so as to unwind the tape from one reel and wind up the tape on the other reel. This direction is reversible to provide fast forward or fast reverse movement of the tape.

Braking wheels 43 and 44 act to provide a drag on the rubber belt 49. Assuming that the tape is on tape supply reel 29 and is being received by takeup reel 36, motor 47 would turn drive wheel 46 in a clockwise direction. Belt 49, frictionally engaged with the periphery of tape 28 on tape supply reel 29, would cause the tape to be unwound from this reel. The friction between belt 49 and the tape on takeup reel 36 will cause takeup reel 36 to wind up the tape. With the tape moving in the direction indicated, the portion of the rubber belt between braking wheels 43 and 44 and drive wheel 46 around idler wheel 40 is stretched while the portion of belt 49 between drive wheel 46 and braking wheels 44 and 43 is relaxed around idler wheel 39. This alternate stretching and relaxation of the belt drive will cause the rubber belt to move takeup reel 36 at a slightly faster rate than is required to receive the tape unwound from supply reel 29. Thus the drive mechanism will automatically adjust to remove any slack from the magnetic tape. If drive wheel 46 is rotated in the opposite direction, that is, counterclockwise, tape is removed from reel 36 and received by reel 29. In this case, the portions of belt 49 which are under tension and which are relaxed are reversed so that reel 29 tends to rotate at a slightly faster rate than reel 36 so that all slack in the magnetic tape will be removed in the reverse operation also.

When tape characters are being read from magnetic tape 28 in other than the indexing mode of operation, pinch wheel 32 is moved by arm 30 against capstan 31 so that tape 28 is controlled by capstan 31. In this mode of operation, motor 47 is nearly stalled and only turns enough to transport the tape pulled by the capstan from one reel and wind it on the other reel. Motor 47 is of a type that will not be damaged when operated in a stalled condition. Power for capstan 31 is provided from motor 18 through helical gears 53 and 54. Helical gear 54 is coupled to shaft 56 through clutch 58. Shaft 56 is coupled to capstan 31 and a brake 59 is coupled to shaft 56 to stop the shaft when required. In operation, the control logic and timing signals from a magnetic track on belt 10 cooperate to intermittently energize and deenergize clutch 58 and brake 59 to provide intermittent tape motion. When clutch 58 is disengaged, brake 59 is energized to stop the movement of the capstan. When clutch 58 is engaged, brake 59 is deenergized to permit capstan rotation.

As tape 28 moves past tape head 33 the information stored on tape 28 is read off and applied to the control logic for use thereby. Information from the control logic is applied to solenoids 64 to set the bubbles on belt 10 in a desired pattern. The timing signals are read from belt 10 by a tape head 61. Variable speed control 22 is set by the operator so that belt 10 will move at a desired speed.

Referring to FIG. 2, there is shown a side view of the belt mechanism. Belt 10 is wound around wheels 11 and 12, 14 and 15 in the manner previously described. The top portion of belt 10, upon which is counterbalanced by counterweight 67 so that it is normally in the raised position shown. When the operator rests his fingers on belt 10, shelf 66 is depressed to position 66a, shown in dashed lines, and remains in this position until the operator removes his hands from the belt. Depressing shelf 66 to position 66a causes bracket 69 to actuate miniature switch 70 to start the operation of the machine. Wheel 14 holds belt 10 under tension under pressure from spring 72. The pressure on belt 10 from wheel 14 against wheel 12 acts to depress all of the raised bubbles to the inside of belt 10, thus presetting belt 10 for the desired pattern formation by solenoids 64.

Referring to FIG. 3, there is shown a section of belt 10. A pair of solenoids 74 and 75 which are used to set the bubbles on the belt in the desired position are also shown. In this example the bubbles to the left of the solenoids are all set in the raised or concave position shown and are stable in this position. (Concave to the person reading the belt.) In the example, solenoid 75 has been operated to depress bubble 76 to a lower or convex position, while bubble 77 remains unchanged as solenoid 74 is not operated. Bubbles 80 and 81 have been previously depressed by the operation of solenoids 74 and 75.

Belt 10 is formed of a plastic material such as polypropylene and the bubbles are molded therein. The molded bubbles are bistable, that is, they will remain in the convex or concave position, such as is exemplified by bubbles 77 and 76, until forcibly moved to the other position. Thus the raised pattern on belt 10, exemplified by bubbles 76, 80 and 81, remains on the belt as it passes under the fingers of the operator until these bubbles are pushed to their opposite position by the pressure of wheel 14 on wheel 12 (FIG. 2).

Referring to FIG. 4, there is shown the pattern of bubbles which is impressed on belt 10. Belt 10 has a series of groups of six bubbles 84 which can be used to form any braille character. Braille characters are formed by one or more of the six positions 83 being moved to a raised or convex position. The use of six positions permits all 63 braille characters to be formed. A magnetic track 85 is also formed on belt 10 and includes timing marks 86 at desired positions in the belt to provide a trigger pulse to the logic when the bubble pattern is properly aligned with the solenoid-actuating mechanism as the belt 10 moves past this mechanism. When a trigger pulse is received, the desired solenoids are actuated to set up a character. Clutch 58 (FIG. 1) is energized to advance tape 28, causing a new character to be read and stored in the machine logic. During reading, belt 10 moves continuously to present the braille patterns to the operator.

FIG. 5 shows the pattern on the magnetic tape 28 of FIG. 1. The magnetic tape contains portions 88 which are reserved for note characters, portions 89 reserved for book characters and portions 90 reserved for indexing characters. The book characters 89 are characters which have been placed on the tape during the prerecording of the tape. These characters may be obtained from ink-printing typesetting tapes which have been translated into braille language or manual translations of ink print material. This presupplied information, while designated as book characters, is not necessarily the output of a book, but may be any kind of reading material.

Index characters 90 are supplied so that the operator can find any desired portions of the tape. Preset switches indicate the desired indexing mark and the tape is rapidly searched until an index character corresponding to the switch setting is found. At this point, the tape is stopped automatically and the operator, after returning the machine to the reading mode, is presented with the exact portion of the tape desired.

Note characters 88 are spaces provided on the magnetic tape where notes can be written so that the tape can be annotated as desired by the operator. It should be noted that a tape containing only note characters can be written by the machine operator and can be read by another machine operator.

An enlarged portion of the note characters portion 88 is shown with a series of note characters 93, 94, and 95. This illustrates that an arbitrary number of note character portions may be positioned together on the tape to receive note characters. Each note character portion consists of a bracket pulse section (BP) 97 followed by an identification (ID) bit section 98 and a braille bit pattern section 99. The bracket pulse section 97 alerts the machine to the fact that a new character is being received. The bracket pulse is present in each of the book character sections and index sections also. The identification portion 98 tells the machine what kind of character, that is, note, book or index, follows. The braille bit pattern 99 tells the machine what particular braille character should be imprinted on the belt. This braille bit pattern only occurs with note or book characters and not with an index character.

Book character sections have an arbitrary number of book characters 101, 102, 103 similar to the note character sections. Each book character consists of a bracket pulse section 105, an identification section 106 and a braille bit pattern 107 similar to the sections of the note characters.

Each index character consists of an index bit pattern 109 followed by a bracket pulse 110 followed by an identification bit pattern 111 and a second index bit pattern 112. The extra index bit pattern 109 preceding the bracket pulse permits a greater number of indexing points that would be possible if only a single index bit pattern were used, yet the machine logic used for the note characters or book characters can be used to process the index bit pattern. Operation of the machine in distinguishing between the various characters will be described in a subsequent portion of the specification. While a particular location of the different character portions has been shown in FIG. 5, it should be noted that any desired intermixture of the book, note and index character portions of the tape may be used as the machine proceeds to the next desired character portion and ignores any in-between characters which are not desired. Book and note character portions are similar in the manner in which they control the machine when the machine is in a reading mode. However, the book character ID bit pattern acts to prevent the machine from stopping at a book character portion when the machine is in a writing mode to prevent destruction of a prerecorded tape.

As show in FIG. 5, a large amount of the control and timing information for the operation of the machine is carried on the tape. This simplifies the control system of the machine, permitting a reduction in its costs and size without a reduction in its capabilities.

Referring to FIG. 6, there is shown the bit pattern which is placed on the tape. Two tape tracks, track A and track B, are used. If a binary 1 is stored on the tape, track A has a 1 and track B has a 0. If a binary 0 is stored on the tape, track A has a 0 and track B has a 1. A 1 is stored on both track A and track B represents a bracket pulse. Blank spaces on the tapes have no pulses. By this means the magnetic tape always has at least one pulse in each recorded position so that it can provide its own clocking pulses for machine operation. Where note character portions are provided on a prerecorded tape, the note character portions have a 0 recorded on the tape so that clock pulses are available.

Referring to FIG. 7, there is shown a block diagram of the data flow and control system logic used with this machine. The motor drive system 115 drives the tape reels 116 and 117 in the manner previously described. Point 118 represents the capstan drive for the magnetic tape 114. Motor drive system 115 also operates belt 120 through drive wheel 121 in the manner previously described. In this drawing, the initials CL represent a connection to control logic 123. These connections have been omitted to provide a clearer drawing.

Assuming that the machine is in the mode of operation to read a prepared tape (read book mode), the operator, by actuating the belt switch 124, sets the machine in operation. Tape 114 is moved past the tape head 126 and the information stored on the tape is read and coupled to tape head switch 127. Since the machine is reading, the information is sent to the read amplifier 128 and amplified thereby. Since at least one pulse is present in each recorded tape position, these pulses are used as a clock signal by data clock 130. The clock signal is coupled to control logic 123 through clock select switch 131. An oscillator 132 provides a clock signal when the machine is in a writing mode and there is no clock signal from the tape 114.

The output of read amplifier 128 is coupled to register 135 and bracket pulse detector 136. Bracket pulse detector 136 detects each bracket pulse and conveys this information to control logic 123 for proper logic control. As data are read from tape 114, they are stepped through register 135 into registers 138 and 139. The timing of the logic and the capacity of registers 138 and 139 is such that the identification bits for the book character 106 of FIG. 5 will be in register 139 and the braille bit pattern 107 of FIG. 5 will be in register 138. At this time in the operation of the machine, character type detector 141 determines that the bit pattern in register 138 is a book character and the information in register 138 is transferred through gate 143 to gate 145. Gate 145 is set to select either register 147 or 148. Each of registers 147 and 148 can hold a number of braille bit patterns and gate 145 is set to a desired register and remains connected to that register until the register is filled. With gate 145 connected to register 147 gate 150 is connected to register 148 to receive the information in register 148. Gates 145 and 150 are always connected to different registers and this operation is controlled by the character register control 151. This logic permits the magnetic tape and the reading belt to operate without requiring synchronization between them as long as the tape is read at a slightly faster rate, when it is in motion, than the belt is imprinted. When the information from the tape fills register 147 and there is information in register 148, the reading of the tape is stopped until register 148 has been cleared by reading out the information therein.

As the information is read out of register 148, the signals are amplified in driver circuit 153 and applied to solenoids 154. Solenoids 154 form the raised characters on belt 120 in the manner previously described according to the braille bit patterns which have been read from tape 114. A magnetic pickup head 156 reads the timing marks on belt 120 to permit operation of the solenoids 154 only when belt 120 is in the proper position for imprinting.

When the operator of the machine desires to read notes which have been placed on tape 114, logic control 123 is placed in he read note mode. The operation of the machine in the read book mode is substantially identical to its operation in the read book mode. In the read book mode, when the identification bits in register 139 indicate that a note character is in register 138, the contents of the register are transferred through gates 143 and 145 to the desired one of registers 147 and 148. In the read note mode book and index characters are ignored.

When it is desired to find a particular index mark, logic control 123 is placed in the index position and index switches 158 are set to the proper position. The output from tape 114 is coupled to registers 135, 138, 139 and register 159. Referring to FIG. 5, it will be noted that the index character pattern includes an additional index bit pattern 109 which precedes the bracket pulse. Thus when register 139 contains the ID bits 111, register 138 contains the index bit patterns 112 and register 159 contains the index bit patterns 109. This provides a substantial increase in the number of index positions which are available. For example, if a six bit index pattern 112 only were used, 63 index positions would be available. By providing the additional index bit pattern 109, the number of index positions available is increased to 4095. By using the coding arrangement shown, the note character and book character portions of the machine can be used to process index bit patterns with only the requirement of an additional register 159. The outputs of registers 138 and 139 are coupled to the index comparing circuit 161. When the numbers in registers 138 and 159 coincide with the number set on index switches 158, tape 114 is stopped and the index position desired has been reached.

In addition to reading tapes, the machine provides for writing of notes. In the note-writing mode, a standard braille keyboard 162 is provided. Braille keyboards are in current use which have six keys and a space bar to form the desired braille pattern. The hammers which imprint the braille medium are driven by the keys through mechanical linkage. To operate with the machine of this invention, it is only necessary to replace the mechanical linkage with switches operated by the keys. The operator uses the keyboard to provide input information to gate 143. This input information is coupled through gate 145 to one of the registers 147 and 148 in the manner previously described. The output of register 147 or 148 is coupled through gate 150 to belt 120 in the manner previously described. This information is also coupled from gate 150 back to register 138 through gate 164.

In operation in the note-writing mode, tape 114 is moved until the ID bits 98 of FIG. 5 of the next available note character are positioned in register 139. At this point the contents of register 138 are read into the tape through write switch 165. The tape then advances to the next note character and the next character put in through keyboard 162 is read into register 138 and from register 138 to the tape through write switch 165, tape head switch 127 and tape head 126. The prerecorded tape has an 0 pattern in all unused note portions so that clock pulses are available. Control logic 123 in the note-writing mode ignores book and index portions so that these prerecorded portions of the tape cannot be altered or destroyed by the machine operator.

In addition to being able to write notes on a previously prepared tape, the machine permits writing in a blank tape. This tape prepared by the machine can be read by another operator on a different machine. To perform this operation, the machine is operated in a manner similar to that used when notes are written. However, since there is no note identification bit present on the tape, the machine provides its own. With the tape prepared to receive information, the desired character is placed in register 138 in the manner described for operation of the note-writing mode. In addition, note identification bits from note encoder 167 are transferred to register 139 and a bracket pulse is transferred from note encoder 167 to write switch 165. The bracket pulse, note identification bits and note bit pattern are transferred to the tape head 126 in the manner previously described. In this mode of operation, clock pulses are provided by oscillator 132. Another operator desiring to read the tape prepared in this manner places his machine in he read note mode and the operation is as previously described.

The embodiments of the invention in which an exclusive property or privilege is claimed are defined as follows:

1. A machine using raised patterns to convey information, including in combination, an endless raising belt, a magnetic tape having a plurality of different information portions thereon with said tape information portions including pluralities of each of character portions, note portions and index portions, with said character portions, said note portions and said index portions being arranged on said tape in a desired sequence, each of said information portions of said tape include a bracket pulse section indicating the beginning of a particular information portion, an identification section for identifying the type of said particular information portion, and an information storage section, tape-reading means, drive means for moving said tape past said tape-reading means to read out the information stored in selected ones of said different information portions, belt-imprinting means, said drive means also acting to move said reading belt past said belt-imprinting means, control means coupled to said drive means, said tape-reading means and said belt-imprinting means, said control means including means for selecting desired ones of said character portions, said note portions, and said index portions, said control means being responsive to said information read out of said selected tape information portion to develop data signals, said belt-imprinting means being responsive to said data signals to form raised patterns on said raising belt, said drive means further including means for removing said raised patterns from said reading belt, input writing means coupled to said control means and generating writing signals representative of desired raised patterns in response to the operation thereof, tape-writing means coupled to said control means and positioned adjacent said tape, said control means further having a writing mode, said control means in said writing mode acting in response to said writing signals to position said note portions of said tape in desired relationship to said tape-writing means, said tape-writing means being responsive to said writing signals to record signals on said tape in said information storage section of said note portion representative of said desired raised patterns.

2. A machine using raised patterns to convey information, including in combination, an endless raising belt, a magnetic tape having a plurality of different information portions thereon, with said tape information portions including pluralities of each character portions, note portions and index portions with said character portions said note portions and said index portions being arranged on said tape in a desired sequence, each of said information portions of said tape including a bracket pulse section indicating the beginning of a particular information portion, an identification section for identifying the type of said particular information portion, and an information storage section, tape-reading means, drive means for moving said tape past said tape-reading means to read out the information stored in selected ones of said different information portions, belt-imprinting means, said drive means also acting to move said reading belt past said belt-imprinting means, control means coupled to said drive means, said tape reading means and said belt-imprinting means, said control means including means for selecting desired ones of said character portions, said note portions and said index portions, said control means being responsive to said information read out of said selected tape information portion to develop data signals, said belt-imprinting means being responsive to said data signals to form raised patterns patterns on said reading belt, and said drive means further including means for removing said raised patterns from said reading belt, input means coupled to said control means and generating writing signals representative of desired raised patterns in response to the operation thereof, tape writing means coupled to said control means and positioned adjacent said tape, said control means further having a writing mode, said control means in said writing mode acting in response to said writing signals to position said note portions of said tape in desired relationship to said tape-writing means, said tape-writing means being responsive to said writing signals to record signals on said tape in said information storage section of said note portion representative of said desired raised patterns, said reading belt being formed of a plastic material with a timing portion positioned along one edge thereof, said timing portion having indexing marks located thereon, a reading head positioned adjacent said belt and coupled to said control means, said reading head being responsive to said indexing marks to develop control signal therefrom, said control means being responsive to said control signals to actuate said belt-imprinting means to cause said raised patterns to be imprinted on said belt in desired locations.

3. A machine using raised patterns to convey braille information, including in combination, a endless plastic reading belt including a plurality of bubbles formed in a desired pattern on said reading belt, each of said bubbles being capable of being in a first position with said bubble extending from one side to said belt and a second position with said bubble extending from the other side of said belt, each of said bubbles being stable in each of said first and second positions, a magnetic tape having a plurality of different information portions thereon with said tape information portions including pluralities of each of character portions, note portions and index portions, with said character portions, said note portions and said index portions being arranged on said tape in a desired sequence each of said information portions of said magnetic

tape including a bracket pulse section indicating the beginning of a particular information portion, an identification section for identifying the type of said particular information section, and an information storage section, tape reading means, drive means for moving said tape past said tape reading means to read out the information stored in selected ones of said different information portions, said drive means including a tape takeup reel and a tape supply reel for carrying said magnetic tape, a movable idler arm positioned between said takeup reel and said supply reel and having idler wheels mounted at each end thereof, braking wheels mounted in said idler arm between said idler wheels, a drive wheel mounted between said takeup reel and said supply reel, a resilient drivebelt positioned under tension around said drive wheel, said braking means and said idler wheels in a configuration such that said tension of said resilient drivebelt urges said resilient drivebelt against said magnetic tape on each of said takeup and supply reels, a motor coupled to said drive wheel for turning the same in a direction so that said resilient drive belt drives said tape supply reel in a direction to remove said magnetic tape therefrom and said tape takeup reel in a direction to receive said magnetic tape thereon, said braking means acting to impede the movement of said resilient drive means whereby a first portion of said resilient drivebelt in contact with said magnetic tape on said tape supply reel is under less tension than a second portion of said resilient drivebelt in contact with said magnetic tape on said tape takeup reel, said difference in tension of said first and second portions of said resilient drive means acting to drive said tape takeup reel at a rate slightly faster than said tape supply reel to remove slack from said tape, belt-imprinting means, said drive means also acting to move said reading belt past said belt-imprinting means, control means coupled to said drive means, said tape reading means, and said belt-imprinting means, said control means including means for selecting desired ones of said character portions, said note portions and said index portions, said control means being responsive to said information read out of said selected tape information portion to develop data signals, said belt-imprinting means being responsive to said data signals to form raised patterns on said reading belt, said drive means further including means fir removing said raised patterns on said reading belt, input writing means coupled to said control means and generating writing signals representative to desired raised patterns in response to the operation thereof, tape-writing means coupled to said control means and positioned adjacent said tape, said control means further having a writing mode, said control means in said writing mode acting in response to said writing signals to position said note portion of said tape in desired relationship to said tape writing means, said tape writing means being responsive to said writing signals to record signals on said tape in said information storage section of said note portion representative of said desired raised patterns.

4. A tape drive mechanism, including in combination, a tape takeup reel and a tape supply reel for carrying magnetic tape, a movable idler arm positioned between said takeup reel and said supply reel and having idler wheels mounted at each end thereof, first braking means mounted in said idler arm between said idler wheels, a drive wheel mounted between said takeup reel and said supply reel, a resilient drivebelt positioned under tension around said drive wheel, said first braking means and said idler wheels in a configuration such that said tension of said resilient drivebelt urges said resilient drivebelt against said magnetic tape on each of said takeup and supply reels, a first motor coupled to said drive wheel for turning the same in a direction so that said resilient drivebelt drives said tape supply reel in a direction to remove said magnetic tape therefrom and said takeup reel in a direction to receive said magnetic tape thereon, said first braking means acting to impede the movement of said resilient drivebelt whereby a first portion of said resilient drivebelt in contact with said magnetic tape on said tape supply reel is under less tension than a second portion of said resilient drivebelt in contact with said magnetic tape on said takeup reel, said difference in tension of said first and second portions of said resilient drive belt acting to drive said takeup reel at a rate slightly faster than said tape supply reel to remove slack from said tape.

5. The tape drive mechanism of claim 4 wherein said resilient drive means is a rubber belt.

6. The drive mechanism of claim 5 further including a second motor, a capstan, a pinch wheel to force said magnetic tape against said capstan, second braking means coupled to said capstan and clutch means coupling said capstan to said second motor, said second braking means and said clutch means being interconnected so that with said clutch means engaged said second braking means is released and with said clutch means disengaged said second braking means engaged means coupled to said second braking means and said clutch means for intermittent operation thereof whereby said movement of said magnetic tape is intermittent.

* * * * *

IV-B-1

DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE
OFFICE OF EDUCATION
WASHINGTON, D.C. 20202

cc: A Grunwald
S Davis
M Abbott

August 17, 1976

RECEIVED
AUG 23 1976
M. PETRICK

Dr. Michael Petrick &
Mr. Arnold Grunwald
Argonne National Laboratory
Engineering Division
9700 South Cass Avenue
Argonne, Illinois 60439

Dear Mike and Arnold,

Enclosed are brochures on the HEW Exhibit: BI-CENT-EX, our bicentennial exhibit. One of the last things that I did as project officer was to work with the designers of the exhibit on the section about the handicapped. The major feature in the special education section is the Argonne Braille Machine. They have it displayed on a square pedestal (same size as the machine); above it are suspended a reel of tape and the belt. Just below the machine is an explanation of how it works. In the background are color photographs of handicapped children and a contrasting braille issue of Readers Digest.

Thanks for your help in providing the machine. Thousands of people will get to see what you have accomplished. If you get to Washington this year, I hope you get to see the exhibit. I will try to get photographs in the next month or so and will send you copies.

Best wishes and good luck with the machine.

Cordially,

John E. Davis
Research Coordinator

Enclosures

[illegible] FOR THE BLIND, Inc.
15 WEST 16th STREET
NEW YORK, N. Y. 10011

IV-C-1

Dr. A. P. Grunwald
Reactor Engineering Division
Argonne National Laboratory
Argonne, Illinois

October 14, 1966

Dr. Philip H. Abelson
The Editor
Science
1515 Massachusetts Avenue, N.W.
Washington, D.C. 20005

Dear Dr. Abelson:

We should like to request 500 reprints of the recent paper by Arnold P. Grunwald, which appeared on pp. 144-146 of the 7 October 1966 issue of Science, to distribute to the members of the IRIS mailing list to whom we have a special relationship; since this many copies may not be available after publication, I wonder whether we might secure permission to reproduce these pages via an Itek offset master copier we have in plant for publications?

This office disseminates information to selected members of the research community engaged in research and development work on sensory devices, and in basic research on sensory processes. Approximately one-quarter of our recipients are outside the U.S.A., distributed among 26 countries (and including members of the Academy of Sciences and Institute of Defectology in the R.S.F.S.R.).

It is my feeling that the description of the prototype model of Dr. Grunwald's device will help answer some persistent questions from our European colleagues about alternative display modes for braille text with the possibility for economical storage. We have not had an opportunity to publish papers describing these efforts in our Research Bulletin, edited by this office. (This journal, published quarterly, attempts to keep the research community informed of advances in the state of the art since the four volumes of the Proceedings of the 1962 International Congress on Technology and Blindness appeared in 1963.)

Although our publications schedule is already set for the next twelve months, it seems to me a pity to miss the chance to inform those members of this special interest research community of this advance.

even though they are not subscribers to Science or members of the AAAS.

Your counsel in the matter would be greatly appreciated.

Cordially yours,

Leslie L. Clark,
Director
International Research
Information Service

cc: ✓Dr. A. P. Grunwald, Argonne, Illinois
M. D. Graham, New York, New York
J. K. Dupress, Cambridge, Mass.

LLC:kb

IV-D-1

ARGONNE NATIONAL LABORATORY

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FEB 13 1970 ABK

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FRIDAY, FEBRUARY 13,1970 FOR IMMEDIATE RELEASE

President Nixon has commended, by means of a personal letter, an Argonne National Laboratory engineer who is working on a braille machine designed to increase the amount of literature available to blind persons.

Arnold P. Grunwald, of Argonne's Engineering and Technology Division, received the following communication from the White House:

> Dear Mr. Grunwald:
>
> I was delighted to learn of the remarkable advance in reading for the blind which the Argonne Braille Machine portends and I want to commend you for your leadership in the development of this important device. By making reading easier for blind persons and by increasing the number of materials available in braille, the Argonne machine promises to bring pleasure as well as personal opportunity into the lives of millions of people throughout the world. It is a pleasure to congratulate you for your part in this important achievement and to wish you continued successes in the years ahead.
>
> With my best wishes to you and your associates,
>
> Sincerely,
>
> Richard Nixon
>
> Mr. Arnold P. Grunwald
> Reactor Engineering Division
> Argonne National Laboratory
> Argonne, Illinois 60439

(more)

The device to which the President's letter refers will take symbols recorded on magnetic tape and play them back as upraised dots--forming the 63 letters in the braille "alphabet"--on an endless plastic belt. A blind person will read information on the moving belt simply by touching the belt with his fingertips, and he will be able to vary the speed of the belt to suit his desired reading speed.

At the end of each pass, the moving belt will be "erased" as new dot patterns are impressed on it.

Grunwald points out that the device should open new horizons for the blind by eliminating the need for cumbersome and costly braille volumes. A conventional braille book, embossed on heavy paper, is about 50 times as bulky as its inkprint counterpart. Recorded on magnetic tape for the Argonne braille machine, the same book would require about as much space as a typewriter ribbon.

Translation of regular printed matter into braille requires the time-consuming labor of highly-trained specialists. Braille printing has to some extent become automated; however, corresponding processes still are costly and require a significant amount of time. Grunwald believes the Argonne machine will go a long way toward solving these problems because it can be made compatible with modern, automated methods of composing ordinary type.

Thus the braille machine may alleviate the problem of storing bulky braille books and make braille material available in greater abundance, Grunwald said, and it should also reduce the cost of creating reading material for the blind and effect considerable savings in post office expense, since mailing costs for braille material in the United States are absorbed by the U. S. government.

(more)

A prototype of this device is in its final development and testing stage. It is hoped that field testing can begin this summer.

Grunwald's work is being carried out under a grant from the U. S. Office of Education.

I·R 100

Award presented to

Argonne National Laboratory

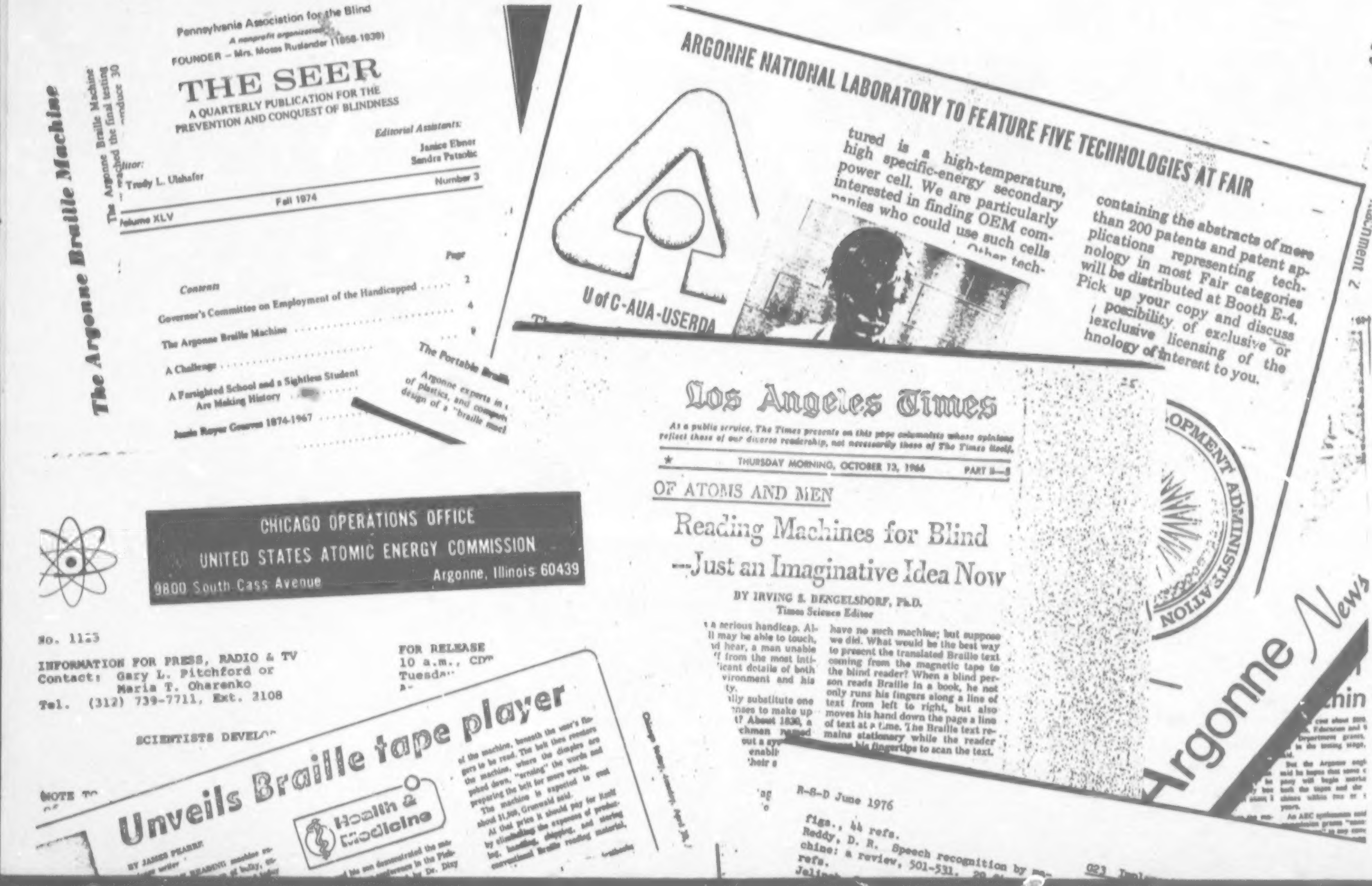
by Industrial Research magazine
for the development of

Argonne Braille Machine

Selected by Industrial Research
as One of the 100 Most Significant
New Technical Products of the Year

1969 Neil Ruzic
editor & publisher

IV-E-1



Pennsylvania Association for the Blind
A nonprofit organization
FOUNDER – Mrs. Moses Rudander (1858-1939)

THE SEER

A QUARTERLY PUBLICATION FOR THE
PREVENTION AND CONQUEST OF BLINDNESS

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Contents

Governor's Committee on Employment of the Handicapped 2
The Argonne Braille Machine 4
A Challenge 9
A Farsighted School and a Sightless Student Are Making History ....
Jessie Royer Greaves 1874-1967 ....

The Argonne Braille Machine

The Argonne Braille Machine ... reached the final testing ... produce 30

The Portable Braille ...

Argonne experts in ... of plastics, and computer ... design of a "braille machine" ...

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...tured is a high-temperature, high specific-energy secondary power cell. We are particularly interested in finding OEM companies who could use such cells ... Other tech-

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CHICAGO OPERATIONS OFFICE
UNITED STATES ATOMIC ENERGY COMMISSION
9800 South Cass Avenue
Argonne, Illinois 60439

No. 1123

INFORMATION FOR PRESS, RADIO & TV
Contact: Gary L. Pitchford or
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FOR RELEASE
10 a.m., CD...
Tuesda...

SCIENTISTS DEVELO...

NOTE TO ...

Los Angeles Times

As a public service, The Times presents on this page columnists whose opinions reflect those of our diverse readership, not necessarily those of The Times itself.

THURSDAY MORNING, OCTOBER 13, 1966 PART II—5

OF ATOMS AND MEN

Reading Machines for Blind —Just an Imaginative Idea Now

BY IRVING S. BENGELSDORF, Ph.D.
Times Science Editor

... a serious handicap. Al... ll may be able to touch, ... and hear, a man unable ... from the most inti... ...icant details of both ... environment and his ...ty. ... ally substitute one ... senses to make up ...? About 1830, a ... chman named ... out a sys... enabl... their ...

have no such machine; but suppose we did. What would be the best way to present the translated Braille text coming from the magnetic tape to the blind reader? When a blind person reads Braille in a book, he not only runs his fingers along a line of text from left to right, but also moves his hand down the page a line of text at a time. The Braille text remains stationary while the reader ... his fingertips to scan the text.

Unveils Braille tape player

Health & Medicine

BY JAMES PEARRE

... of the machine, beneath the user's fingers to be read. The belt then reenters the machine, where the dimples are poked down, "erasing" the words and preparing the belt for more words.

The machine is expected to cost about $1,500, Grunwald said.

At that price it should pay for itself by eliminating the expenses of producing, handling, shipping, and storing conventional Braille reading material.

... and his son demonstrated the machine ... conference in the ... by Dr. Dixy ...

Argonne News

... Braille Machin...

R-&-D June 1976

figs., 44 refs.
Reddy, D. R. Speech recognition by machine: a review, 501-531. 29 ... refs.
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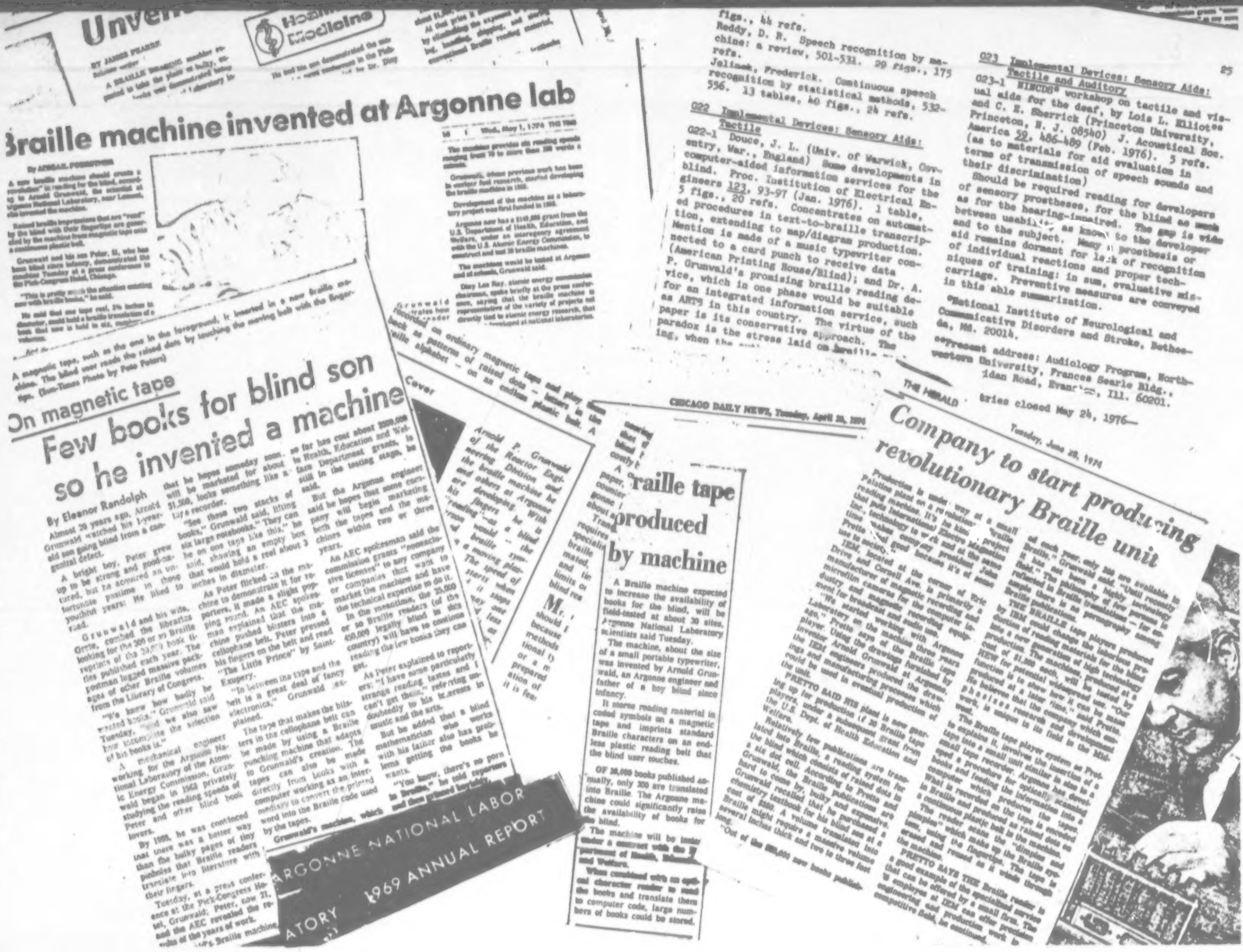

Braille machine invented at Argonne lab

Wed., May 1, 1974

Grunwald and his son Peter, 21, who has been blind since infancy, demonstrated the machine Tuesday at a press conference in the Pick-Congress Hotel, Chicago.

The machine provides six reading speeds ranging from 70 to more than 200 words a minute.

Grunwald, whose previous work has been in nuclear fuel research, started developing the braille machine in 1963.

Development of the machine as a laboratory project was first funded in 1966.

Argonne now has a $149,000 grant from the U.S. Department of Health, Education, and Welfare, under an interagency agreement with the U.S. Atomic Energy Commission, to construct and test 30 braille machines.

The machines would be tested at Argonne and at schools, Grunwald said.

A magnetic tape, such as the one in the foreground, is inserted in a new Braille machine. The blind user reads the raised dots by touching the moving belt with the fingertips. (Sun-Times Photo by Pete Peters)

On magnetic tape

Few books for blind son so he invented a machine

By Eleanor Randolph

Almost 20 years ago, Arnold Grunwald watched his 1-year-old son going blind from a congenital defect.

A bright boy, Peter grew up to be strong and good-natured, but he acquired an unfortunate pastime in those youthful years: He liked to read.

Grunwald and his wife, Grete, combed the libraries looking for the 300 or so Braille reprints of the 20,000 book titles published each year. The postman lugged massive packages of other Braille volumes from the Library of Congress.

"We knew how badly he wanted books," Grunwald said Tuesday, "and we also saw how incomplete the selection of his books is."

A mechanical engineer working for the Argonne National Laboratory of the Atomic Energy Commission, Grunwald began in 1963 privately studying the reading speeds of Peter and other blind book lovers.

By 1966, he was convinced that there was a better way than the bulky pages of tiny pinholes that Braille readers translate into literature with their fingers.

Tuesday, at a press conference at the Pick-Congress Hotel, Grunwald, Peter, now 21, and the AEC revealed the results of the years of work.

Grunwald's Braille machine, that he hopes someday soon will be marketed for about $1,500, looks something like a tape recorder.

"See these two stacks of books," Grunwald said, lifting six large notebooks. "They can be on one tape like this," he said, showing an empty box that would hold a reel about 3 inches in diameter.

As Peter flicked on the machine to demonstrate it for reporters, it made a slight popping sound. An AEC spokesman explained that the machine pushed blisters into a cellophane belt. Peter pressed his fingers on the belt and read "The Little Prince" by Saint-Exupery.

"In between the tape and the belt is a great deal of fancy electronics," Grunwald explained.

The tape that makes the blisters in the cellophane belt can be made by using a Braille punching machine that adapts to Grunwald's creation. The tapes can also be made directly from books with a computer working as an intermediary to convert the printed word into the Braille code used by the tapes.

Grunwald's machine, which so far has cost about $500,000 in Health, Education and Welfare Department grants, is still in the testing stage, he said.

But the Argonne engineer said he hopes that some company will begin marketing both the tapes and the machines within two or three years.

An AEC spokesman said the commission grants "nonexclusive licenses" to any company or companies that want to market the machine and have the technical expertise to do it.

In the meantime, the 25,000 or so Braille readers (of the 450,000 legally blind in this country) will have to continue reading the few books they can get.

As Peter explained to reporters: "I have some particularly strange reading tastes and I can't get them," referring undoubtedly to his interests in music and the arts.

But he added that a blind mathematician who works with his father also has problems getting the books he wants.

"You know, there's no porn in Braille," he told reporters and then grinned broadly.

Grunwald illustrates how reader recorded on ordinary magnetic tape and play back as patterns of raised dots — letters in the braille alphabet — on an endless plastic belt.

Cover

Arnold P. Grunwald of the Reactor Engineering Division and the braille machine he and others at Argonne are developing. With his fingers he is "reading"—as a blind person would—the braille symbols on a moving plastic belt. The speed of

ARGONNE NATIONAL LABORATORY 1969 ANNUAL REPORT

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figs., 44 refs.

Reddy, D. R. Speech recognition by machine: a review, 501-531. 29 figs., 175 refs.

Jelinek, Frederick. Continuous speech recognition by statistical methods, 532-556. 13 tables, 40 figs., 24 refs.

G22 Implemental Devices: Sensory Aids: Tactile

G22-1 Douce, J. L. (Univ. of Warwick, Coventry, War., England) Some developments in computer-aided information services for the blind. Proc. Institution of Electrical Engineers 123, 93-97 (Jan. 1976). 1 table, 5 figs., 20 refs. Concentrates on automated procedures in text-to-braille transcription, extending to map/diagram production. Mention is made of a music typewriter connected to a card punch to receive data (American Printing House/Blind); and Dr. A. P. Grunwald's promising braille reading device, which in one phase would be suitable for an integrated information service, such as ARTS in this country. The virtue of the paper is its conservative approach. The paradox is the stress laid on braille

25

G23 Implemental Devices: Sensory Aids: Tactile and Auditory

G23-1 NINCDS* workshop on tactile and visual aids for the deaf, by Lois L. Elliot** and C. E. Sherrick (Princeton University, Princeton, N. J. 08540) J. Acoustical Soc. America 59, 486-489 (Feb. 1976). 5 refs. (as to materials for aid evaluation in terms of transmission of speech sounds and their discrimination)

Should be required reading for developers of sensory prostheses, for the blind as much as for the hearing-impaired. The gap is wide between usability as known to the developer and to the subject. Many a prosthesis or aid remains dormant for lack of recognition of individual reactions and proper techniques of training: in sum, evaluative miscarriage. Preventive measures are conveyed in this able summarization.

*National Institute of Neurological and Communicative Disorders and Stroke, Bethesda, Md. 20014.

**Present address: Audiology Program, Northwestern University, Frances Searle Bldg., idan Road, Evanston, Ill. 60201.

tries closed May 24, 1976—

CHICAGO DAILY NEWS, Tuesday, April 30, 1974

Braille tape produced by machine

A Braille machine expected to increase the availability of books for the blind, will be field-tested at about 30 sites, Argonne National Laboratory scientists said Tuesday.

The machine, about the size of a small portable typewriter, was invented by Arnold Grunwald, an Argonne engineer and father of a boy blind since infancy.

It stores reading material in coded symbols on a magnetic tape and imprints standard Braille characters on an endless plastic reading belt that the blind user touches.

OF 30,000 books published annually, only 300 are translated into Braille. The Argonne machine could significantly raise the availability of books for the blind.

The machine will be tested under a contract with the U.S. Department of Health, Education and Welfare.

When combined with an optical character reader to read the books and translate them to computer code, large numbers of books could be stored.

THE HERALD Tuesday, June 25, 1974

Company to start producing revolutionary Braille unit

Production is under way at a small Palatine plant on a revolutionary Braille reading machine. It's the kind of project that puts International Electro Magnetics Inc., technology to work and at the same time makes company president John Pretto feel good because it's of some use to society.

IEM, located at the corner of Eric Drive and Cornell Ave., is primarily a manufacturer of magnetic recording and microfilm cameras for the computer industry and magnetic recording equipment for broadcast and audio use.

"We started working with Argonne Laboratory on the machine three years ago," Pretto says of the Braille tape player. Using the drawings furnished by inventor Arnold Grunwald at Argonne, the IEM engineers produced the drawings and manufacturing processes which could be used in eventual production of the unit.

PRETTO SAID HIS plant is now gearing up for production of 30 Braille tape players, under a subsequent grant from the U.S. Dept. of Health Education and Welfare.

Relatively few publications are translated into Braille, a reading system for the blind which consists of raised dots in a six dot cell. According to Pretto and Grunwald, the Braille publications are hard to come by, bulky and expensive. Grunwald recalled that he purchased a chemistry textbook for his blind son at a cost of $350. A volume translated into Braille might require a massive volume several inches thick and two to three feet long.

"Out of the 800,000 new books published each year, only 300 are available in Braille," Grunwald said. "Until recently it has not been a highly technology field." The philosophy of few persons is reflected in Braille translations — for example there is no pornography among Braille publications.

THE BRAILLE tape players produced by IEM could change the laborious production of reading materials for the blind into a new generation of high technology production. The machines, produced at a cost of $1,500 each, will be tested by HEW for potential widespread use. "Our function is to show how it can be mass produced at a later time," said Pretto. He believes that the company which emphasizes research and development work, is unique in its field in the Midwest.

The Braille tape player system as Pretto explains it, involves the insertion of a tape into a small unit similar in size to a small tape recorder. Argonne has developed a procedure for optically scanning books and feeding the information into a computer which produces the tapes. What is recorded on the tape is encoded in Braille and produced as raised dots on a continuous plastic belt in the machine.

The reader scans the "dimples and pimples" which make up the Braille system, using the fingertips. The tape is erased and reused as it winds through the machine.

PRETTO SAYS THE Braille reader is a good example of the specialized service that can be offered by a small firm. The 75 employes at IEM can offer precision engineering and production work in a competitive field, he continued.